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ACQUISITION STRATEGY IMPLICATIONS OF A LONG RANGE COMBAT AIRCRA--ETC(U)
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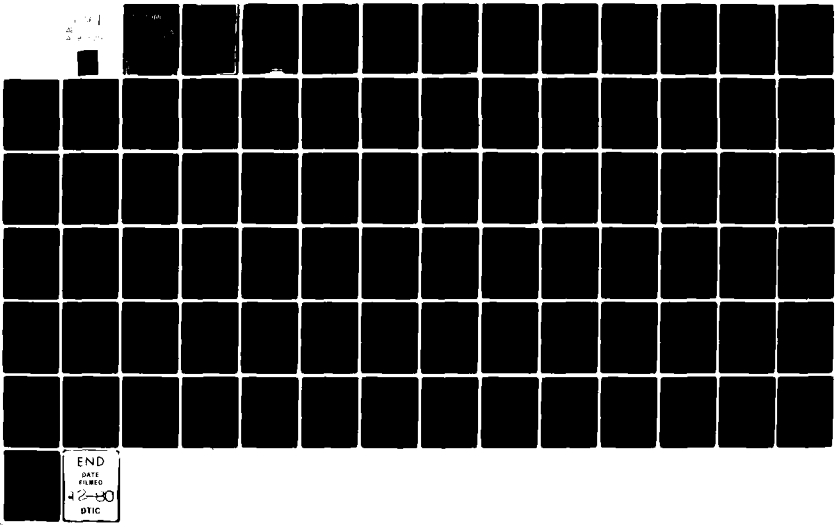

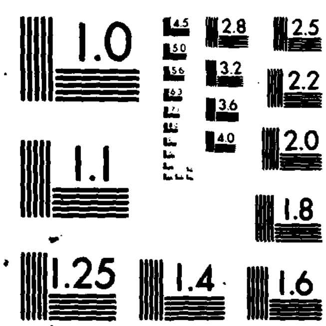

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ACQUISITION STRATEGY IMPLICATIONS OF A LONG RANGE COMBAT AIRCRAFT (LRCA)

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DEPUTY FOR DEVELOPMENT PLANNING
AERONAUTICAL SYSTEMS DIVISION
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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NOTICE

This technical report has been reviewed and is approved for publication.

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During the first quarter of 1980, the Secretary of the Air Force expressed interest in the Long Range Combat Aircraft (LRCA) concept and requested its assessment. The assessment of the concept included definition of a number of generic aircraft designs, evaluation of their cost/effectiveness, and consideration of the practical implications of acquiring such a system. This report contains a discussion of the acquisition implications of ~~LRCA~~ to include: affordability, availability, logistics, and SALT II aspects. (over)

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Assessment of the LRCA concept involved consideration of two alternative program schedules, Milestone II - 1981, and Milestone II - 1985, and thus, consideration of a near term and mid-term technology level. Since the LRCA is in a pre-Milestone 0 status, no firm conclusions regarding an ultimate program can be reached; results of this assessment would support some preliminary implications. For the LRCA to be affordable, requires that substantive reprogramming of the budget be undertaken, more importantly, the priority of the program must be sustained throughout the acquisition cycle. The availability of resources to support the LRCA requires planning and management and does not present insurmountable difficulties. The initial operational capability (IOC) may, depending on the exigency of the need, not be when one may wish it. Full capability is most likely not possible prior to the mid-1990s. The final design of the LRCA and its weapons complement are dependent upon consideration of the Strategic Arms Limitation Treaty (SALT II) as ratified.

FOREWORD

This document was prepared to record the results of an effort to assess the business oriented aspects of acquiring a Long Range Combat Aircraft (LRCA). This effort was undertaken during the period from February until June of 1980 and involved the participation of a number of Aeronautical Systems Division (ASD) deputates. Since the LRCA is in a pre-Milestone '0', feasibility assessment, need identification phase it must be recognized that the topics addressed herein are not to be considered conclusive; however, it is considered essential to address them at this time, if only in a preliminary basis.

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ACKNOWLEDGEMENT

This document represents the collective thoughts of a spectrum of Aeronautical Systems Division personnel within a variety of functional areas. Principal contributors included:

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	-	Mr. R. Morris	Materials Availability
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ACQUISITION STRATEGY IMPLICATIONS
OF A
LONG RANGE COMBAT AIRCRAFT (LRCA)

I. INTRODUCTION

The Long Range Combat Aircraft (LRCA) concept evolved during the fourth quarter of 1979 after the cancellation of the Penetrating Manned Bomber program during the FY 80 budget cycle. Its evolution was in response to the perceived need for a new aircraft to perform the spectrum of military operations the aging B-52 fleet currently performs.

The implications of this aircraft were addressed during a 29-30 January 1980 symposium at Air University hosted by Dr. H. Mark, Secretary of the Air Force. On 26 February 1980, Dr. Mark sent a memorandum to attendees concerning Large Warfighting Aircraft. He also chartered the USAF Scientific Advisory Board (SAB) to review LRCA in a 1980 summer study. In sending the memorandum to Lt Gen Skantze, ASD Commander, the Secretary of the Air Force requested ASD's thoughts on LRCA by 1 June 1980 for incorporation into a package for Dr. Brown, Secretary of Defense.

Mr. S. A. Tremaine, Deputy for Development Planning, was subsequently appointed as senior level special assistant for LRCA technology. Mr. Tremaine formed an ad hoc committee which included support from ASD, AFWAL, FTD, AFWL, SAC, TAC, and Armament Division. The objective was to formulate the corporate ASD thoughts on LRCA for General Skantze' input to Dr. Mark and the SAB.

The LRCA committee consists of seven panels: acquisition strategy, mission definition, technology, payload definition, aircraft design, survivability, and cost/effectiveness.

The overall task of the committee is essentially a program risk assessment. Risk, as classically defined, being the probability that the system will not be delivered within cost, on schedule, and to specification. It is the objective of the Acquisition Strategy Panel to treat two of the parameters of the risk equation, affordability and availability; the third, capability, will be addressed by the remaining panels.

As indicated in DoDI 5000.2, the validity of program decisions depends upon the quality of cost, schedule, and performance estimates. " . . . Although there is considerable uncertainty early in the acquisition process, every effort must be made to use the best available data and techniques in developing estimates . . ." Since the LRCA has not reached the Milestone '0', program initiation point, "considerable uncertainty" is inherent in the estimates.

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II. ALTERNATIVE PROGRAMS

Two alternative LRCA programs have been defined using the Milestone II decision point as the focus. These points are:

1. December 1981 Milestone II, and

2. Fourth Quarter 1985 Milestone II.

This approach was taken to permit a discussion of variations in technology and vehicle effectiveness associated with a near-term and a far-term alternative. The technology and capability discussion will be reserved for other sections of the LRCA report. This document addresses the practical considerations constraining the program alternatives.

Prior to the initiation of substantive efforts under either of the schedules, it is necessary that a Milestone 0 decision be reached. This decision by the Secretary of Defense (SECDEF) consists of the "identification and definition of a specific mission need to be fulfilled, the relative priority assigned within the agency, and the general magnitude of resources that may be invested," and as such definitely colors the entire program. The Air Force, thus far, has had limited success in reaching this point regarding a large warfighting aircraft.

A. DECEMBER 1981 MILESTONE II. This alternative was developed assuming that the SECDEF could confirm the urgency of the perceived need for a current technology large warfighting aircraft and, simultaneously, identify a preferred solution concept (i.e., long range, subsonic, low altitude, etc.). While this alternative may not be likely, or even desirable, it serves to identify the constraints of a "near-term" solution. Exercise of this alternative is within the discretion of the SECDEF under the major system acquisition policy of OMB Circular No. A-109, and is termed an "Accelerated Compliance Program."

The schedule as shown in Figure 1 has at least two alternatives. The first is a funded contract definition phase in lieu of the unfunded RFP cycle suggested. Albeit, the Office of Federal Procurement Policy has recently been critical of unfunded contract definition proposal cycles; within the accelerated schedule, a funded request for proposal (RFP) was not considered feasible. The second alternative considered is a draft RFP. Again, this is a desirable technique; however, infeasible within the time frame. Early release of a "draft" RFP would necessitate that the Air Force have its RFP, describing the requirements in "mission terms," prepared. Preparation of even a draft of such an RFP would neressitate an extensive analytical effort. This schedule would not accommodate such an effort before release of the formal RFP. Consequently, the schedule contemplated is an unfunded contract definition effort.

Figure 1 is a schedule of the events between Milestone 0 (the identification and definition of a specific mission need and the selection of the preferred solution concept), and Milestone II (commitment to full-scale engineering development (FSED) and limited production). Due to the

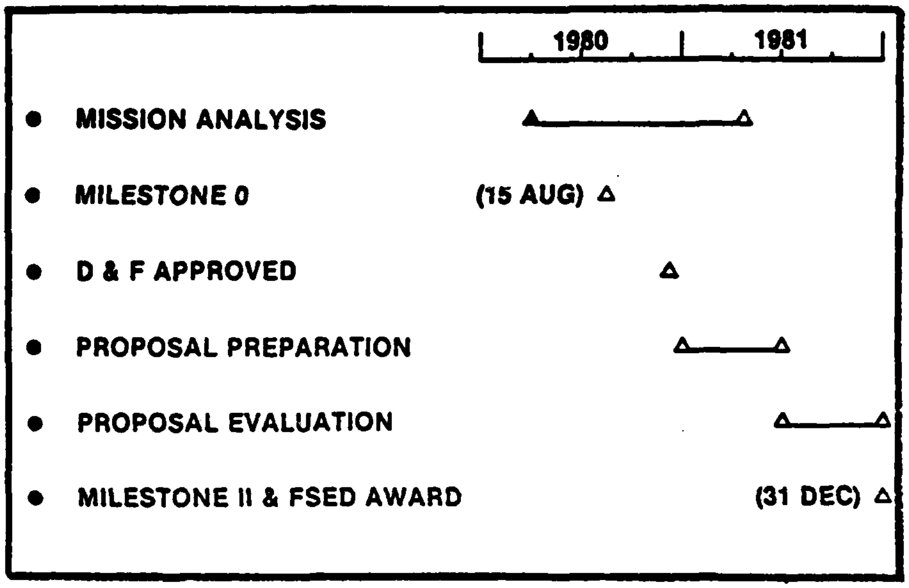

Figure 1. Accelerated Compliance Schedule - Milestone II 1981

time constraints, the major task between these two points is the definitization of the FSED contract. Intermediate events and associated caveats are:

1. Mission Analysis. This effort involves an extensive evaluation of the interaction of threat, operational concepts, and other factors which affect and support both the definitization of the mission need and preparation of the request for proposal for FSED. Due to the compressed schedule, the primary thrust would be to support preparation of the FSED RFP.

2. Milestone 0. The SECDEF identifies a preferred solution concept and validates a mission need which he intends to satisfy. The "identification of the preferred solutions concept" is a key assumption in this alternative as it would obviate the need for a Phase 0, concept exploration effort. The preferred solution concept would be a relatively conventional design if the program to be defined at the Milestone II point, only seventeen months later, is to be of an acceptable risk.

The Secretary of Defense Decision Memorandum (SDDM), which documents the Milestone 0 decision, validates the mission need, and establishes the program goals, thresholds, and objectives, authorizes exceptions to the established acquisition policy, and provides direction and guidance to OSD, OJCS, and the Air Force for the contract definition activities.

3. Secretarial Determination and Finding (D&F) Approval. A D&F for authority to negotiate a contract for the Full-Scale Engineering Development (FSED) and limited production of the LRCA is required. It is anticipated that the FSED program will include a total of four (4) Research, Development, Test and Evaluation (RDT&E) aircraft plus static and fatigue articles. The limited production will include quantities sufficient to support an Initial Operational Capability (IOC) of one squadron of 15 aircraft. Long leadtime authorization for materials and a number of waivers necessary to tailor the program acquisition strategy will be included in this request.

The D&F approval provides the authority to issue the formal Request for Proposal (RFP). This schedule assumes priority handling of the D&F request, as ninety (90) days is allowed for the review and approval cycle as opposed to the generally experienced 120 days.

4. Proposal Preparation. As previously discussed, there are significant advantages to having preceded the formal RFP with a draft RFP; however, the compressed schedule does not permit this. The draft RFP could be beneficial in this instance to permit clarification of ambiguities before issuance of the formal RFP. Under this accelerated compliance schedule, any ambiguities must be clarified during the six months solicitation time. This time is considered necessary for industry to assimilate and analyze the RFP which defines the need in "mission terms" so that a design meeting the preferred solution concept may be generated.

5. Proposal Evaluation. This event involves a formal source selection under AFR 70-15. Commonly, the proposals are in two installments. The first, the technical management and logistics proposal, which constitute the bulk of the materials necessary for the evaluation. The second installment is the cost data necessary to support the proposed price. An allowance of an additional 30 days for submission of cost data is normal.

This FSED proposal would include the RDT&E aircraft and efforts, and also an option for limited, low rate production of the LRCA. The intervening schedule of contractual reviews, which leads to the next major decision point, Milestone III, Production and Deployment, are of particular concern.

At the time of receipt of the proposal, the Government must have the approved evaluation criteria for the source selection. Since the RFP has described the need in mission terms as opposed to specifications, this criteria will include the evaluation of proposed concepts against standard missions (scenarios). This connotes a large scale model to be used in the evaluation.

The total of six (6) months has been allowed for source selection. Considering the in-depth analysis necessary for this process and the

magnitude of the contemplated contract, this is a minimum time period. Additionally, it is anticipated that the source selection decision will be retained at the SECAF, if not the SECDEF, thus, necessitating an extensive formal review prior to final selection.

6. Milestone II and FSED Award. The Defense System Acquisition Review Council (DSARC), which advises the SECDEF on milestone decisions for major systems, will be required to review and render its decision within 30 days after source selection. DoDI 5000.2, paragraph C.4.d, Milestone Planning Schedule, specifies that a milestone planning meeting occur six months prior to the DSARC, which is coincident with the source selection.

B. FOURTH QUARTER 1985 MILESTONE II. This alternative program was predicated on the assumption that full-compliance with the major system acquisition policy as embodied in DoDD 5000.1 would be required for the LRCA. In this alternative, program initiation is preceded by a Mission Analysis Phase. This pre-Milestone 0 phase will generate the rationale for the Milestone 0 decision, and has been included to counter such perceptions as that of the GAO which recently indicated " . . . to our knowledge, there is no plan or strategy that assesses the total need for an effective bomber force into the 1990s and beyond . . ." Additionally, the Mission Analysis Phase will generate the programmatic basis upon which to predicate the goals and thresholds established with the Milestone '0' SDDM.

Figure 2 is a schedule of the intermediate events between Milestone 0 and Milestone II. This schedule includes a Milestone I decision, which is a selection of the system design concepts to be advanced to the demonstration/validation phase or authorization to proceed with the development of a single concept. The nature of the Milestone I decision, and the structure of the subsequent program will depend upon the acceptability of the program risks of the selected concept. Again the SECDEF guidance within the SDDM will color the entire program.

The intermediate events and associated caveats are:

1. Mission Analysis. This will be an assessment of the capability to conduct a broad range of operations in support of national objectives, and an evaluation of the interplay of threat, capability, operation concepts, and other factors that affect the accomplishment of these operations. This will be conducted at the Product Division with support from both the using commands and the Air Force Laboratories. Data generated shall support the Milestone 0 decision by providing rationale and programmatic information upon which to base program goals and thresholds. During the mission analysis, participation by industry would be desirable to identify technological opportunities and alternative solutions. Participation of the operating command is imperative.

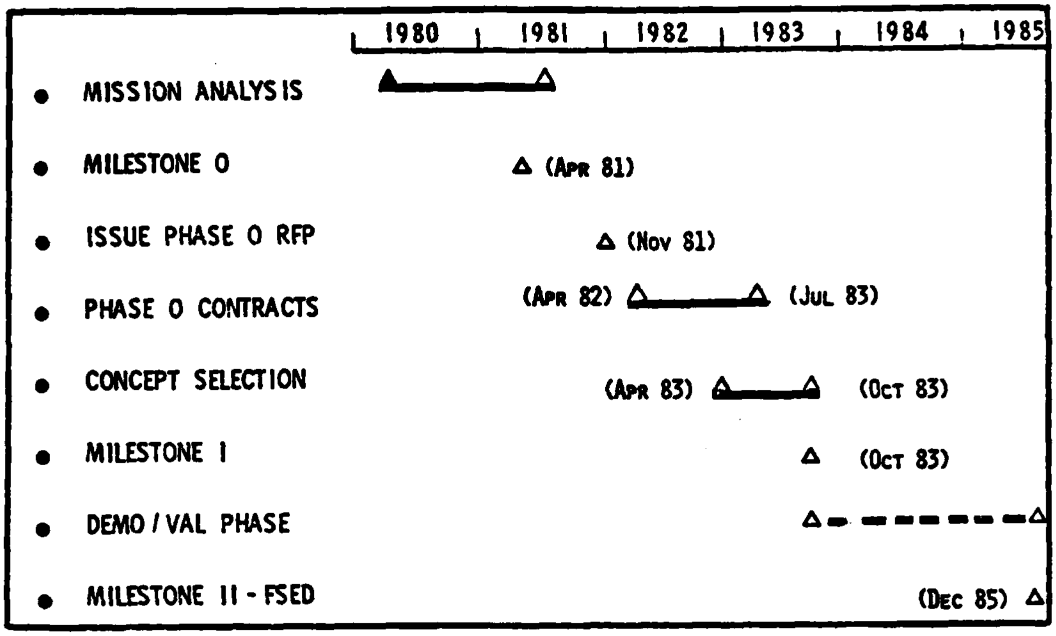

Figure 2. Full Compliance Schedule - Milestone II 1985

2. Milestone 0 - This entails the approval, by the Secretary of Defense, of the Mission Element Need Statement (MENS), and the authorization of Phase 0, Concept Exploration, activities. These activities include the solicitation, evaluation, and competitive exploration of alternative system concepts. This Milestone 0 decision differs from the 1981 alternative since no preferred solution concept is identified. Upon receipt of program direction at Milestone 0, efforts toward awarding Phase 0 contracts are initiated. The D&F authorizing the negotiation of multiple Phase 0 contracts for the identification and exploration of alternative concepts to satisfy the mission need must be requested and approved prior to release of the RFP.

3. Issue Phase 0 RFP - Issuance of this RFP marks the start of proposal preparation by industry. This RFP will "outline the need in mission terms, schedule objectives and constraints, systems cost objectives, and operating and deployment constraints." This method of defining the need permits the widest possible competition between alternative solution concepts and facilitates the selection of a "preferred" solution concept. Since the effort in the Phase 0 RFP is one of a concept exploration, the proposal preparation time is 60 days. Upon receipt of the proposal, a source selection will be conducted to select those contractors that have a capability to develop the LRCA.

4. Phase 0 Contracts. Multiple contracts will be awarded in Phase 0. The contractors shall work in parallel, to a common statement of work. The number of contracts is dependent upon the funds available.

5. Concept Selection. An AFR 70-15 source selection will be held to select the concept or concepts, to be pursued into the subsequent program phases. The results of this selection, and the data submitted under the Phase 0 contract, will provide the basis for the Milestone I decision. Full documentation and deliberation necessary to support a DSARC I is assumed.

6. Milestone I. The concept selected at Milestone I greatly determines the strategy for the subsequent phases. The necessity and extent of Phase I efforts are dependent upon the level of risk of the selected concept(s). Current major system acquisition policy permits at the Milestone I the advancing of the selected concepts into demonstration/validation or authorizing the development of a single concept. If the concept selected is of relative low risk and conventional design, the necessity for a demonstration/validation effort would be eliminated.

7. Demonstration/Validation Phase. It is not now possible to define the nature or extent of this Phase; consequently, the length is conjectural. For example, if the risk associated with the selected concept dictates that a prototype be built and tested, the period shown may not be adequate. Conversely, if a conventional design was selected and the concomitant risk was acceptable, the necessity for this phase may be obviated.

Due to the anticipated complexity of the avionics suite envisioned for the LRCA variants, significant benefit could be realized from conducting avionics architecture development activities during this phase. These activities, to include demonstration hardware, would lower the FSED risk and possibly eliminate avionics architecture and computer resources as critical paths of the LRCA program.

8. Decision Process. This decision process is equivalent to a source selection and would support the Milestone II decision. Again, this decision is dependent upon the concept(s) selected in Milestone I.

9. Milestone II. FSED - This event authorizes full-scale engineering development of the LRCA and reflects the SECDEF's intent to deploy the system. This decision includes authorization for limited production to support testing requirements and the defined IOC of a squadron of aircraft. Consideration would be given to the life cycle affordability of the LRCA and to the necessity for long lead authorization and acceptable degree of concurrency in the program.

III. AFFORDABILITY

The DoDD 5000.1 provides that affordability is " . . . a function of cost, priority, and availability of fiscal and manpower resources . . ." During this assessment, efforts were concentrated on the development of life cycle cost estimates for the aircraft concepts considered, the identification of fiscal resources available to support the acquisition of this system, and the comparison of perceived funding demands with the planned availability of funding.

A. LIFE CYCLE COSTING

There were two basic objectives of the Life Cycle Cost Analysis. The first was to develop relative 20-year life cycle costs for each design option for use in the cost-effectiveness analysis. The second objective was to address affordability. Both sets of estimates were based on very preliminary configurations and program data costs and should be considered from a relative standpoint only.

A special Life Cycle Cost (LCC) model was developed for LRCA. Since buy quantities were not available, relative LCCs were calculated in terms of cost versus quantity equations. Therefore, a separate equation is provided for each design option. Every equation took the form:

$$\text{Cost} = A + BQ + CQ^D \qquad (1)$$

Where:

A = FSED RDT&E costs in billions of FY 80 dollars

B = the per unit Operation and Support (O&S) costs for 20-years. When multiplied by a given quantity "Q", we obtain 20-year operation costs in billions of FY 80 dollars

CQ^D = the total production costs at quantity "Q" and reflects a composite cost-quantity relationship where "D" approximates the learning equation.

A, B, C and D are constants in the equation for each design option. The sum of "A" (RDT&E), "BQ" (O&S), and "CQ^D" (Production) is, therefore, the total life cycle cost.

1. Methods and Assumptions. The overall basis for projecting LRCA R&D and Production costs was to extrapolate from the last B-1 Independent Cost Analysis (ICA) cost estimates made prior to terminating the B-1 production program. This required conversion of the B-1 estimate to FY 80 dollars and extrapolating from this estimate to properly adjust for design and performance differences between the B-1 and the LRCA options. The methods by which such adjustments were made varied for different cost components and are discussed in the sections that follow. Major RDT&E and production cost elements are addressed in separate sections.

The LRCA life cycle cost estimates presented in this report do not include 6.2 and 6.3 funding prior to the FSED start (DSARC II) decision. The B-1 program included $139M then-year dollars for advanced development, not included in the basis used to extrapolate the LRCA RDT&E estimates. This money spent in the late 1960s would be equivalent to over 350 million in FY 80 dollars. If the LRCA program requires LRCA specific advanced development funds, they would be in addition to the FSED funds contained in the relative LCC estimates provided herein. This omission should have little effect on relative LRCA option life cycle costs, especially among design options having the same assured FSED start date.

The relative life cycle cost estimates do not include the costs of weapons expended in wartime. Peacetime weapon operations, maintenance and training costs are considered only to the extent that AFR 173-13 addresses them with respect to B-52 operations. Therefore, the fact that some design options may use more or less expensive weapons, is not reflected in the relative life cycle cost estimates.

2. RDT&E

a. Airframe. The LRCA airframe cost estimates were made using the DAPCA III Cost Model developed by the RAND Corporation. The model, which is based on the costs of many old aircraft, was calibrated and adjusted to provide a B-1 production cost estimate roughly equal to the last ICA B-1 production cost estimate. Further adjustments were made to the model or model results to match an engineering judgment that the production cost difference of a supersonic bomber should be no more than 25 percent more than the production cost of a subsonic bomber of the same weight. A further upward adjustment to the model results was made because the model indicated that the difference between subsonic bomber and cargo RDT&E costs for aircraft of the same weight was less than 8 percent. This adjustment increased subsonic LRCA airframe development RDT&E costs to a value exceeding cargo aircraft development costs by about 25 percent of the difference between the cost to develop the B-1 airframe and a cargo aircraft airframe of the same weight. This was judged a reasonable added cost to cover added testing, extensive subsystem integration, RCS reduction, RAM, nuclear hardening, etc., and cost not applicable to cargo aircraft.

Once the procedures and factors were established to adjust the model and the results generated by the model, the adjustments were kept constant for all LRCA options. Therefore, the adjustment process had little or no bearing on relative LRCA option cost estimates.

b. Engines

(1) F-101-GE-102 and JT9D Engines. These engines have been qualified for production with the exception of minor modifications. The estimates for these engines are based on earlier studies and represents the cost of qualifying the modifications, engine/airframe integration, flight test hardware and support of a minimum level flight test program.

(2) F101/F21 Engine. This engine will be a derivative F101 engine. Therefore, the current F101 Derivative Fighter Engine (DFE) independent ASD/YZ estimate was scaled to account for changes in thrust

and additional complexity of the F101/F21 engine. With adjustments for economics, thrust, and complexity, the F101/F21 estimate is bounded by B-1/F101 development costs and F101 DFE development costs. The complexity assessment was made by ASD/YZ engineers with experience in both the B-1/F101 program and the F101 DFE program.

(3) New Technology Engine. This R&D estimate is based on the F101 development cost history. The F101/B-1 development cost was adjusted for economics and the lack of a demonstrator engine for component testing. Both the F100 and F101 engine technology had been tested in a demonstration engine prior to program initiation. This is not the case with the proposed engine where components for a demonstration engine will not be available until 1983. The real development costs for this engine are estimated to be greater than the historical F101 or F100 development program costs.

c. Avionics. The LRCA avionics RDT&E costs were factored based on the last B-1 ICA avionics development cost estimate, with appropriate adjustments for base year, scope of the avionics suite and the percent of new design. All costs were adjusted to base year 1980 dollars using the AFSC 110 Report factors.

Analysis methods to take into consideration the percent of new avionics design were developed by making parametric runs using the RCA PRICE Model. These methods and judgments of ASD and AFAL engineers with respect to the percent new design in the B-1 avionics suite and the percent new design in various LRCA suites were used to consider differences in the amount of new design in various avionics suites. The adjustment factor equation developed was:

$$F = (.47 + .0023 \times \text{percent new design}) \div .562 \qquad (2)$$

To adjust for the differences in scope of the B-1 and LRCA avionics suites, a list of 54 avionics equipment functions, 31 of which essentially described the B-1 suite, was prepared. This list was then given to the avionics specialists to change as required to develop a list of LRCA avionics suite functions. In addition, those proposing items for the LRCA suites, also gathered as much cost data as possible on new items. The head of the avionics suite description team and cost analysts then compared the B-1 avionics suite functions lists with that of the LRCA suite lists and reviewed the available new equipment cost data, to estimate a factor relating the scope LRCA suite to the scope of the B-1 avionics suite. The LRCA avionics development costs were then computed by obtaining the product of the B-1 avionics RDT&E costs in 1980 dollars, the adjustment factor for percent new design and the LRCA option scope difference factor. The scope and percent new design factors used for such LRCA design option are shown in Table 1.

d. Other. The other RDT&E costs, to cover support equipment, training, etc., were developed by using a ratio. This ratio was the same as the ratio of the other RDT&E costs to the sum of airframe, engine and avionics RDT&E costs contained in the most recent B-1 ICA. It was .08 percent.

TABLE I. LRCA DESIGN OPTION DESCRIPTION SUMMARY

AIRCRAFT * DESIGNATION	ENGINE TYPE/NR.	ENGINE THRUST	AMPR WEIGHT	FUEL GPH	AVIONICS SCOPE	% NEW AVIONICS
11432	JT9D/2	56,000	107,104	2,408	1.4	40
11653	JT9D/3	56,000	138,700	2,207	1.4	40
11864	JT9D/3	56,000	158,808	2,594	1.4	40
21642	F101-102/4	30,750	123,380	4,018	1.5	40
21653	F101-102/4	30,750	162,640	4,369	1.5	40
21864	F101-102/4	30,750	182,980	4,178	1.5	40
15432	New/4	23,180	104,103	1,461	1.9	90
15653	New/4	27,090	151,630	1,584	1.9	90
15851	New/4	25,500	131,942	1,475	1.9	90
15864	New/4	30,600	169,890	1,918	1.9	90
25432	F101-21/4	37,100	99,511	3,438	2.0	90
25643	F101-21/4	37,100	119,050	4,933	2.0	90
25653	F101-21/4	37,100	150,920	3,658	2.0	90
25864	F101-21/4	37,100	171,260	3,682	2.0	90

* Configuration Code

Code Number = T_y S R GPT_a (6 digit)

T_y = Type , 1 = Conventional

2 = Low Observable

S = Schedule , 1 = Milestone II - 1981

5 = Milestone II - 1985

R = Runway Length (feet) (4, 6, and 8 x 10^3 feet)

G = Gross Weight (pounds) (3, 4, 5, and 6 x 10^5 pounds)

P = Payload, Number of Weapon Bays (1, 2, 3, and 4 bays)

*T_a = Tanker used. (This parameter does not affect the LCC)

3. Production Costs

a. Airframe. The DAPCA III cost estimating model developed by the RAND Corporation was used to develop parametric LRCA airframe cost estimates. The model which is based on the cost of many of the aircraft was calibrated and adjusted to provide a B-1 cost estimate roughly equal to the last B-1 ICA cost estimate. A further adjustment was made to the model to match an engineering judgment that the production cost differences between a supersonic and subsonic bomber should not be more than 25 percent. Further adjustments were made to:

(1) Obtain results in FY 80 dollars.

(2) Give credit for unspecified MANTECH improvements resulting in a 10 percent reduction in manufacturing labor hours. This factor remained constant for all relative cost estimates for the cost benefit analysis. However, it could be used to refine estimates for specific design for which specific MANTECH programs are described.

(3) Increase material costs due to the impact of fuel cost increases over and above inflation, on high technology, primarily heat treated materials.

b. Engines

(1) F101-GE-102 Engine. The production estimate was based on the current F101 estimates for the FB-111H program. This estimate was based on B-1 history and was adjusted to reflect the size of procurements planned for the LRCA system.

(2) JT9D Engine. This estimate represents the current commercial price of this engine as quoted by the contractor. Following commercial practices, the estimates for differing sized buys vary strictly as a function of the number of engines.

(3) F101/F21 and New Technology Engines. The production cost of these engines was estimated based on current production estimates of the F101 Derivative Fighter Engines. Since evidence indicates that large engines of similar type vary in cost as a function of thrust, the F101-DFE estimate was modified for differences in thrust and size of procurements.

c. Avionics. The LRCA avionics production costs were factored from the most recent B-1 ICA estimate, adjusted for the difference in the scope of the LRCA avionics suite, quantity differences and inflation. The methods of developing scope changes were described in paragraph 2.c., above. The quantity changes were made using a 90 percent aggregate cost quantity slope, because that slope was used in the most recent B-I ICA.

c. Peculiar Support. The peculiar support cost estimate was based on a factor relative to the total of airframe, engine and avionics costs. This factor was taken from the latest B-1 ICA and was 7.6 percent.

e. Initial Spares. The peculiar support cost estimate was based on a factor relative to the total airframe, engine and avionics costs. It includes engine spares. The factor was taken from the latest B-1 ICA and was 6 percent.

4. Twenty-Year O&S Costs

a. Fuel Costs. Twenty-year fuel costs were developed on a per aircraft basis as a function of:

(1) Average hourly fuel consumption rate for a specific LRCA design option.

(2) The fraction of aircraft produced assumed to be being operated at any one time (.88).

(3) Assumed flyaway hours per year, 240.

(4) 1980 fuel costs per gallon, $1.18.

(5) An aggregate 2.65 factor to cover increases in fuel costs over and above inflation over the 20-year operating life cycle. This resulted in a 20-year LRCA fuel cost equation in FY 80 dollars of:

$$\text{FUEL COST} = \$13{,}000 \text{ per gal per flying hour per aircraft produced} \tag{3}$$

b. Twenty-Year O&S Less Fuel Costs. The twenty-year O&S cost less fuel was developed by extrapolating from current B-52 O&S costs as reported in the "USAF Planning Factor Guide." The O&S less fuel costs for B-52D/G/H operations were used. Adjustments were made based on the relative flyaway costs of B-52 and LRCA aircraft. In addition, a 20 percent O&S cost reduction was used for LRCA aircraft for assumed reliability, maintainability, supportability improvements and projected reductions in the flying hour program. This resulted in a 20-year O&S less fuel cost equation of:

$$\text{TWENTY-YEAR O\&S LESS FUEL COSTS} = 1.87 \times \text{average unit flyaway cost} \tag{4}$$

5. Life Cycle Costing Results

Table 1 briefly describes the 14 LRCA design options for which life cycle cost estimates were made. Table 2 provides the 20-year life cycle cost equations and cost estimates for quantities of 50, 100 and 200 for each of the 14 LRCA options studies. Note from Table 2, the life cycle cost for a quantity of 100 ranged from 20 to 45 billions of FY 80 dollars. The fact that the most expensive options to develop and require less fuel, tends to make this range less than one might think.

TABLE 2. TWENTY-YEAR LIFE CYCLE COST EQUATIONS AND COST ESTIMATES

A/C DESIGNATION	COST EQUATION PARAMETERS*				20-YR LCC ESTIMATE ($ IN BILLIONS)		
	A	B	C	D	QTY 50	QTY 100	QTY 200
11432	3.424	.17471	.27955	.74799	17.4	29.6	53.1
11653	3.873	.19968	.32798	.75153	20.1	34.2	61.4
11864	4.144	.21788	.35775	.74832	21.7	37.1	66.7
21642	3.659	.22001	.34834	.73398	20.8	35.9	64.7
21653	4.195	.25049	.40821	.73075	23.9	41.0	73.9
21864	4.457	.26089	.43781	.72955	25.1	43.1	77.6
15432	5.486	.17875	.31919	.74234	20.3	33.1	57.6
15653	6.156	.21599	.39927	.73746	24.1	39.6	69.3
15851	5.887	.19965	.36586	.73917	22.5	36.8	64.2
15864	6.397	.23479	.43012	.73679	25.8	42.6	74.7
25432	4.662	.21211	.32834	.74638	21.4	36.0	64.2
25643	4.950	.24528	.36048	.74316	23.8	40.5	72.5
25653	5.390	.25000	.40933	.73970	25.3	42.7	76.0
25864	5.659	.26340	.43942	.73792	26.7	45.1	80.3

* Where costs in billions of FY 80 $ $= A + BQ + CQ^D$

Q = Production quantity with 80 percent being deployed with operational units.

** See configuration definitions as foot-noted in Table 1.

The total twenty-year life cycle costs include development costs for the airframe, engine, avionics and peculiar training and support equipment. It included production costs for the airframe, engine, avionics, training equipment and spares. Also included were 20-year operating costs which cover all O&S costs addressed in the USAF Cost and Planning Factors Guide for current aircraft.

6. Conclusions

Useful relative twenty-year life cycle costs were developed for cost benefit analysis. These estimates should also be useful for a first look at affordability. However, much more would have to be known about the product and the program before high confidence can be placed in such estimates. Specifically, more information is needed on:

a. Specific material requirements.

b. Specific manufacturing plans.

c. Performance requirements.

d. Design and design risks.

e. Operational concepts.

f. Maintenance concepts.

g. Test program requirements.

h. Detailed and realistic schedules.

i. Specific LRCA Advanced Development Program requirements.

B. COST/RESOURCE ASPECTS OF AFFORDABILITY

The DoDD 5000.1 and DoDI 5000.2 provides that in assessing affordability one should resort to both the Five-Year Development Plan (FYDP) and the Extended Planning Annex (EPA) in defining the resources available to support the program. An attempt to utilize the information in the December 1979 EPA to define a funding "window" was less than successful. The source for the identification of the LRCA "window" was a Hq USAF/PAXEB affordability study which was conducted in support of the January 1980 Program Objective Memorandum (POM) review. This study, is indicated to have been based on the EPA, the President's Budget, and USAF/RD inputs. This "window" is denominated the New Bomber and was used as a basis of comparison for postulated LRCA development schedules.

For purposes of this effort, it was assumed, and Hq USAF personnel concurred, that the LRCA would replace a yet to be determined number of B-52s, therefore, operations and support affordability could not be properly addressed. Only RDT&E and production costs were compared and discussed relative to affordability.

To put LRCA RDT&E and production costs in perspective, comparable costs were obtained for the B-1 and MX programs. Additionally, the LRCA RDT&E and production costs were compared to the New Bomber "window." The

New Bomber aircraft were not described in the Hq USAF report nor any other sources reviewed. The production quantity for the B-1 was 241 units. The cost data for the B-1 program was taken from the most recent B-1 ICA and adjusted for inflation. The MX program data were obtained from Hq AFSC/ACCI.

Table 3 shows relative LRCA RDT&E costs and Table 4 shows relative production costs for all LRCA design options for which cost estimates were developed.

TABLE 3. RELATIVE LRCA RTD&E COSTS (FY 80 $ IN BILLIONS)

DESIGN OPTION *	COST
11432	3.4
11653	3.9
11864	4.1
21642	3.7
21653	4.2
21864	4.5
15432	5.5
15653	6.2
15851	5.9
15864	6.4
25432	4.7
25643	5.0
25653	5.4
25864	5.7

* Configuration Code

Code Number = Y_y S R GPT_a (6 digit)

T_y = Type , 1 = Conventional
2 = Low Observable

S = Schedule, 1 = FY 81 DSARC II
5 = FY 85 DSARC II

R = Runway Length (feet) (4,6, and 8 x 10^3 feet)

G = Gross Weight (pounds) (3, 4, 5, and 6 x 10^5 pounds)

P = Payload, Number of Weapon Bays (1, 2, 3, and 4 bays)

TABLE 4. RELATIVE LRCA PRODUCTION COSTS (FY 80 $ IN BILLIONS)

DESIGN OPTIONS *	COSTS 50	100	200
11432	5.2	8.7	14.7
11653	6.2	10.4	17.6
11864	6.7	11.2	18.9
21642	6.2	10.2	17.1
21653	7.1	11.8	19.6
21864	7.6	12.5	20.9
15432	5.8	9.7	16.3
15653	7.2	11.9	20.0
15851	6.6	11.0	18.4
15864	7.7	12.7	21.4
25432	6.1	10.2	17.2
25643	6.6	11.0	18.5
25653	7.4	12.3	20.6
25864	7.9	13.1	22.0

* See Note Below Table 3.

The following costs in billions of FY 80 dollars were used in developing the cost comparison figure format:

	DEVELOPMENT	PRODUCTION
B-1	6.5	22.8
MX	7.6	24.8 (includes military construction)
NB	4.6	8.3

Table 5 shows how the total new bomber values were broken out by year. Figure 3 is a summary graph showing the band of estimates for all 14 LRCA design options.

Several significant general observations can be drawn from the information contained in the figures and tables. First, RDT&E requirements for all LRCA design options studied are always below the B-1 and MX programs' RDT&E requirements and straddle the new bomber RDT&E requirement.

TABLE 5. NEW BOMBER FUNDS CITED IN AFFORDABILITY STUDY

(FY 80 $ IN MILLIONS)

YEAR (FY)	81	82	83	84	85	86	87	88	89	90	91	92
RDT&E	18	46	92	276	459	918	918	918	489	489	28	--
PRODUCTION							92	551	1652	2019	1927	2019

Adjusted for inflation from the FY 80 $. Data provided by AF/PA.

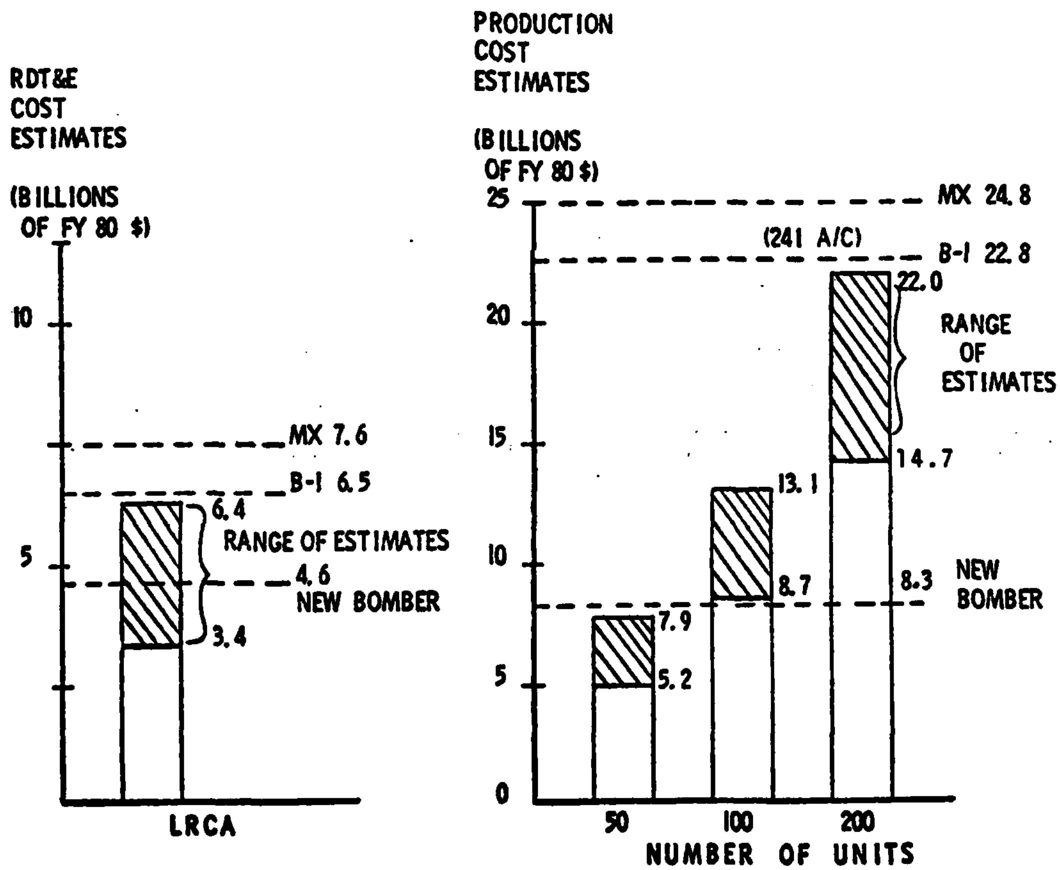

Figure 3. Long Range Combat Aircraft (LRCA) - Program Cost Estimate Comparison

A second observation is that all 100 unit LRCA design option production program cost estimates exceed the production program funding level included in the Hq USAF affordability study for a new bomber program. All 100 unit production program cost estimates are well below the MX and B-1 production program estimates.

Figures 4 and 5 use two of the 14 design options to represent the differences in funding profiles between the 1981 and 1985 FSED start programs. The Figure 5 profile represents a program with a 1985 FSED start date. Its funding profile is clearly more compatible with the Hq USAF affordability study profile than the 1981 FSED start data program shown in Figure 4. Current projections for MX funding requirements in the 1983-1987 time period are very high and would argue strongly against the affordability of a LRCA with a 1981 FSED start date. The MX profile is overlaid on each figure.

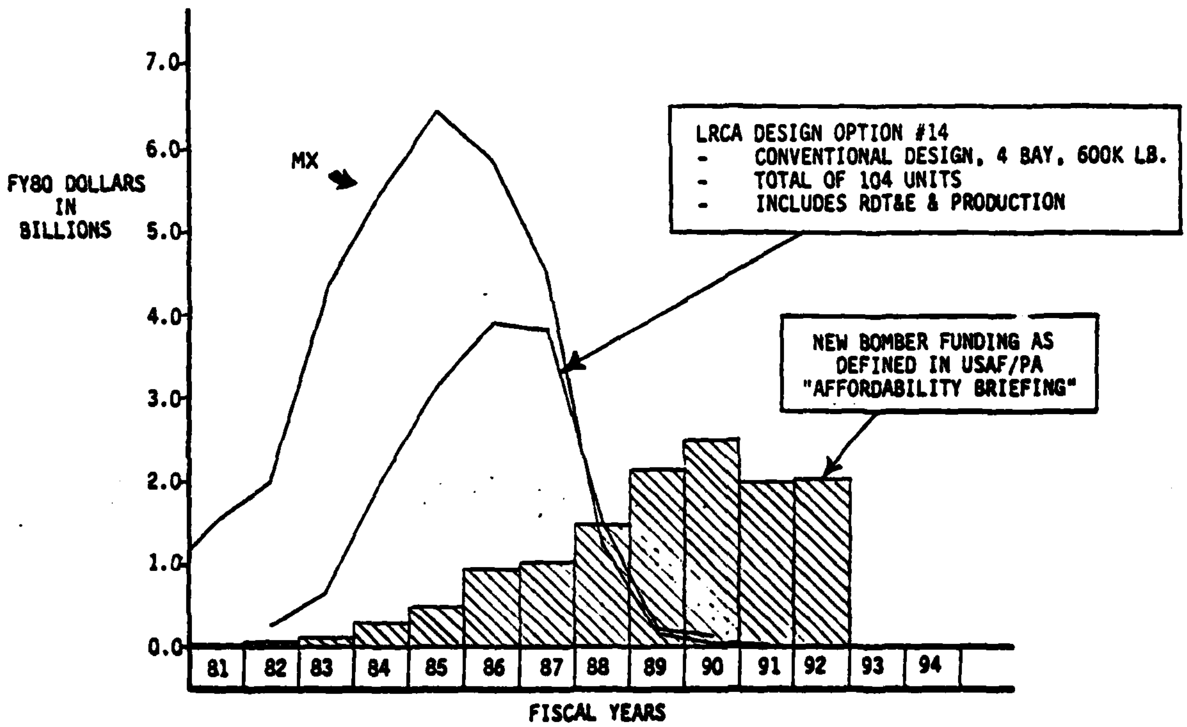

Figure 4. Long Range Combat Aircraft Affordability - Milestone II - 1981

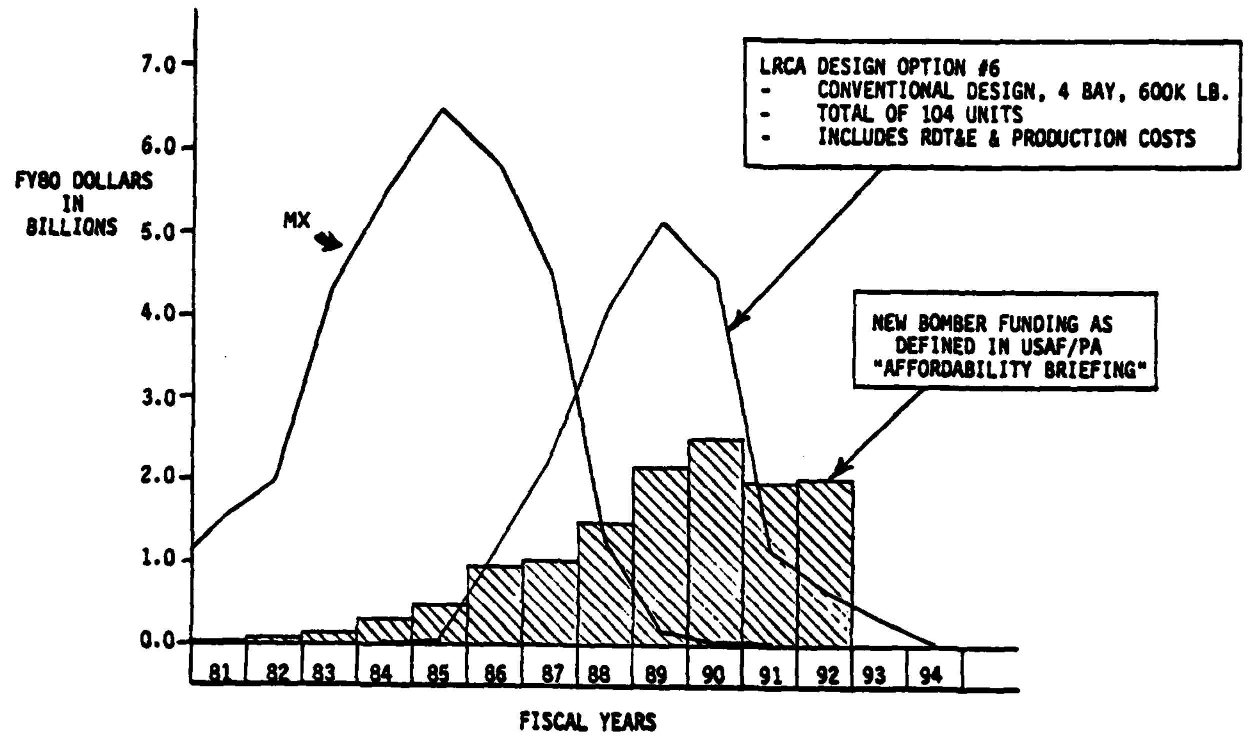

Figure 5. Long Range Combat Aircraft Affordability - Milestone II - 1985

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IV. AVAILABILITY

The "availability" parameter is not defined in either DoDD 5000.1 or DoDI 5000.2. It has been construed here as addressing the realism of the schedule associated with the alternatives discussed in Section II, above.

In addition, it specifically addressed the lead times associated with critical elements of the program and postulates representative schedules leading from the alternative Milestone II decision points to an initial operational capability (IOC). For purposes of this exercise IOC has been defined as a squadron of aircraft (15 units). A reasonable FSED program would involve four flight, one static, and one fatigue article. Therefore, a total of 21 airframes will be necessary to support an IOC.

The issue of "timeliness" as presented in current major systems acquisition policy, and which may be allied with the issue of availability, is not addressed. This is primarily because "the time dictated by the need or threat" has not been established and accepted at all levels. It is assumed, however, that there is a degree of urgency associated with the need. Unfortunately, absent a wartime environment, an extensive FSED program is envisioned, and the degree to which the acquisition cycle may be minimized is limited consistent with program risk.

A. ENGINE OPTIONS

One of the availability drivers of LRCA is the engine. Historically, engine development leadtimes have approached those of the full weapon system. While it is necessary to define the technical/performance requirements of an engine before one can intelligently establish an acquisition strategy and schedule for development of a new engine, a schedule, as depicted in Figure 6, is not unlikely. Since such a schedule is not likely to be compatible with the aircraft program, the acquisition strategy may dictate that the Air Force develop the engine and furnish it as GFE to the airframe manufacturer. Lessons learned on previous engines and their development indicate that extensive lead-in testing is required to prove the design, performance, and reliability of the engine. For the alternative LRCA schedules considered, the development of a "new" centerline engine is not considered feasible. Should, however, an alternative LRCA schedule be selected, it may be feasible and desirable to develop a new centerline engine.

A number of engines were considered initially (Figure 7); however, the following engine options are recommended for the Long Range Combat Aircraft program as currently defined:

1. <u>Milestone II - 1981</u>

The F101-GE-100 engine (for the low observables aircraft) and the Pratt & Whitney JT9D-70 engine (for the conventional aircraft) are off-the-shelf engines and, therefore, are considered low risk. As such, these engines could readily be contracted as GFE. Since these engines have already been qualified/certified, no engine FSED phase is required.

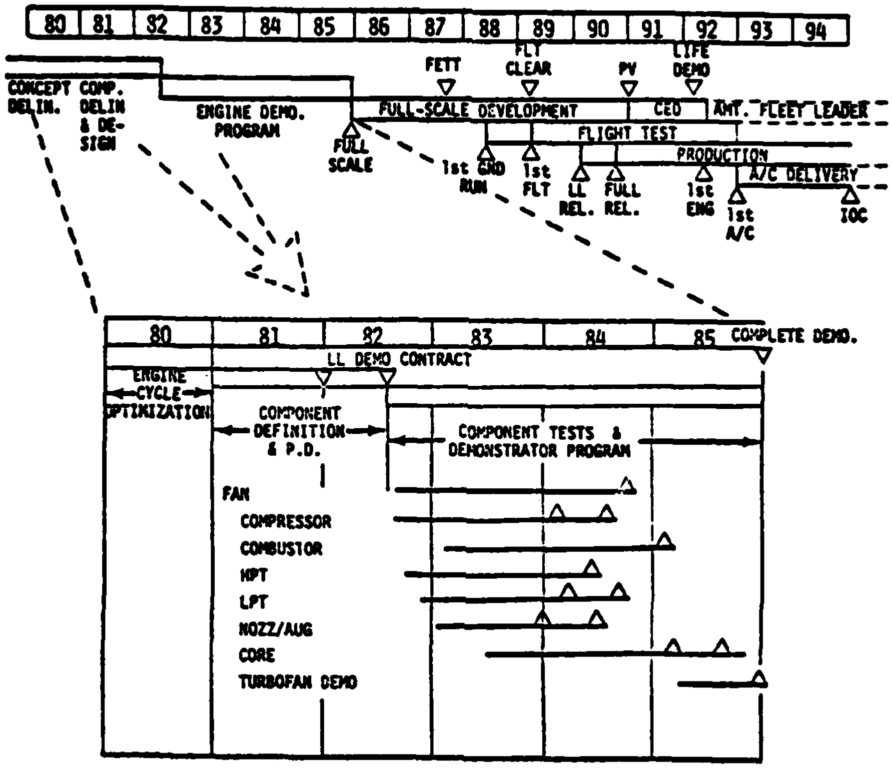

Figure 6. New Engine Development Schedule

ENGINE	STATUS	RISK	CAPABILITY
TF-34	P	1	SUPERSONIC
F-100	P	1	"
F-101	P	1	"
F-404	P	1	"
JT-9D	P	1	SUBSONIC
CF6-50	P	1	"
CFM-56	P	1	"
JT-10 D-232	D	2 - 3	"
CF6-32	D	2	"
E^3 - GE (GE 31/F-1 Study C1)	T	3	"
E^3 - P&W (STF 505M-7C)	T	3	"
JTDE	T	3 - 4	SUPERSONIC
ATEGG	T	4	"

STATUS - P = Production, qualified configuration (within 48 months)
- D = Development, configuration not qualified (within 7 years)
- T = Technology demonstration, no configuration (within 7 years)

RISK 1 = Low; 4 = High

Figure 7. Candidate LRCA Engines

2. Milestone II - 1985

The GE F101-F21 Study A-1 Engine and the GE 31/F1 Study C-1 Engine for the low observables aircraft and the Pratt & Whitney STF 505M-7C Engine for the conventional aircraft would be representative of the development required. These engines are considered high risk since there is not any existing demonstrated hardware. These engines could be bought as either Contractor Furnished Equipment (CFE) or Government Furnished Equipment (GFE). Should they be contracted as CFE, only one source selection would be required; whereas, if they were GFE, a separate source selection would be required. Due to the complexity factor, we recommend the engines be acquired as GFE so the Government can keep closer control.

In conclusion, until the performance requirements are established (which usually necessitates a series of design/requirements iterations), it is not possible to confidently define the LRCA engine acquisition strategy. Key requirements include: range, penetration capability, prelaunch survivability, fuel efficiency, etc. These factors are normally defined in the concept exploration phase.

B. MATERIAL LEADTIMES

The aerospace industry's concerns over materials and leadtimes have seldom been greater than they are today. The Air Force's current major aircraft programs have experienced leadtime increases ranging from 12 to 20 months since their production began. Leadtimes for materials, components and subsystems are a key factor: the landing gear alone for the A-10 now requires over 4 years; the leadtimes for the F-100 engine and the ACES II seat have extended to 3 years. Of the two proposed Milestone II decision schedules for the LRCA, the first places the program in a period of continuing strong demand for aerospace products, while the second places it in a period during which market conditions are less certain. This subsection examines four vital areas of the LRCA:

- The system and its materials requirements;
- Outlook for materials and industrial capacity;
- Schedule considerations/constraints; and
- Impact of a DX rating.

Where appropriate, anticipated situations and conditions during both 1981 and 1985 are considered and compared.

1. The Systems and Its Materials Requirements. As a large warfighting, subsonic aircraft, the LRCA can probably be produced primarily with conventional materials such as aluminum. There will be some titanium requirements, but they should be minimal compared to those of the B-1. Requirements for more exotic materials and super-alloys will probably be greatest in the engine.

a. Airframe. It is difficult to determine specific materials requirements for an undefined aircraft, but by using the parametric estimates of projected AMPR weights and other airframes as models, it is possible to make estimates for key materials. Three estimated AMPR weights for the LRCA were considered. The projections of gross materials

requirements are based on these estimates, with approximately 90 percent of the gross requirement expected to consist of aluminum (65 percent), steel alloys (15 percent), and titanium (10 percent). Figure 8 shows the LRCA's projected needs for these materials.

ESTIMATED GROSS MATERIAL WEIGHTS

PROJECTED AMPR WEIGHT (LBS)	ESTIMATED GROSS WEIGHT*	ALUMINUM	STEEL ALLOYS	TITANIUM	TOTAL THREE MATERIALS
99,511	284,317	184,806	42,648	28,432	255,886
	221,136	143,738	33,170	22,114	199,022
	199,022	129,364	29,853	19,902	179,119
150,920	431,200	280,280	64,680	43,120	388,080
	335,378	217,996	50,307	33,538	301,841
	301,840	196,196	45,276	30,184	271,656
171,260	489,314	318,054	73,397	48,931	440,382
	380,578	247,376	57,087	38,058	342,521
	342,520	222,638	51,378	34,252	308,268

* The estimated gross weights and subsequent aluminum, steel alloy and titanium requirements are based on "fly to buy" estimates of 35%, 45% and 50% (i.e., the amount of initially purchased material that actually becomes part of the airframe).

Figure 8. Estimated LRCA Materials Requirements

Figure 8 offers three gross weight estimates for each projected AMPR weight. These figures reflect estimated "fly to buy" percentages of 35, 45, and 50 percent. The 35 percent projection is the most conservative, showing nearly two-thirds of the airframe's gross material requirement being machined away during manufacture. The 45 percent and 50 percent estimates are more optimistic and partially reflect the potential for improved materials utilization through manufacturing technology applications.

The gross materials weight may be further broken down into estimates of the forms required to produce the aircraft. Approximate percentages for various forms are:

Aluminum	Sheet, Plate	-	18%
	Extrusions	-	38%
	Forgings	-	36%
	Rods, Bars	-	8%
Steel Alloys	Forgings	-	53%
	Rods, Bars	-	47%
Titanium	Forgings	-	50%
	Extrusions	-	35%
	Rods, Bars	-	15%

Knowing the quantity and composition of materials' requirements is critical to understanding the system's impact on the marketplace. ASD/PMD recently participated in a study of the CX's potential impact on the commercial aerospace market. It was discovered that heavy press and hammers are at virtual capacity and will be for up to five more years. The CX was expected to create an additional demand of nearly five percent in the already choked aluminum forgings market of the early 1980s. If the LRCA enters FSED and production between 1981 and 1985, it could conceivably compound the problem.

b. Engines. The engine options for the LRCA are more clearly defined than the airframe. The Pratt & Whitney JT9D and the General Electric F101 are the primary candidates. Their requirements for selected critical and strategic materials are:

MATERIAL	JT9D	F101
Titanium	11,600 lb	4,090 lb
Cobalt	1,070 lb	330 lb
Chromium	7.200 lb	1,160 lb
Tantalum	35 lb	70 lb
Nickel	11,700 lb	3,190 lb
Columbium	300 lb	120 lb

From a critical materials' requirements standpoint, the F101 is preferable to the JT9D. The anticipated availability of materials and components is discussed below.

2. <u>Outlook for Materials and Industrial Capacity</u>

a. Military/Commercial Aerospace Demand. Demand from military and commercial aerospace programs is currently pushing suppliers of some materials and components beyond their capacity limits. Domestic titanium sponge capacity has been outstripped by demand, heavy forgings

capacity is booked up to three years, and capacity for some forms of aluminum will soon be committed through 1982. This situation, coupled with the high cost and uncertain availability of such strategic materials as cobalt and tantalum, has created problems for the industry despite its current prosperity.

Military aircraft deliveries are expected to peak in 1981, while commercial demand should remain strong through 1985 (Figure 9). It is important to note that annual commercial demand for

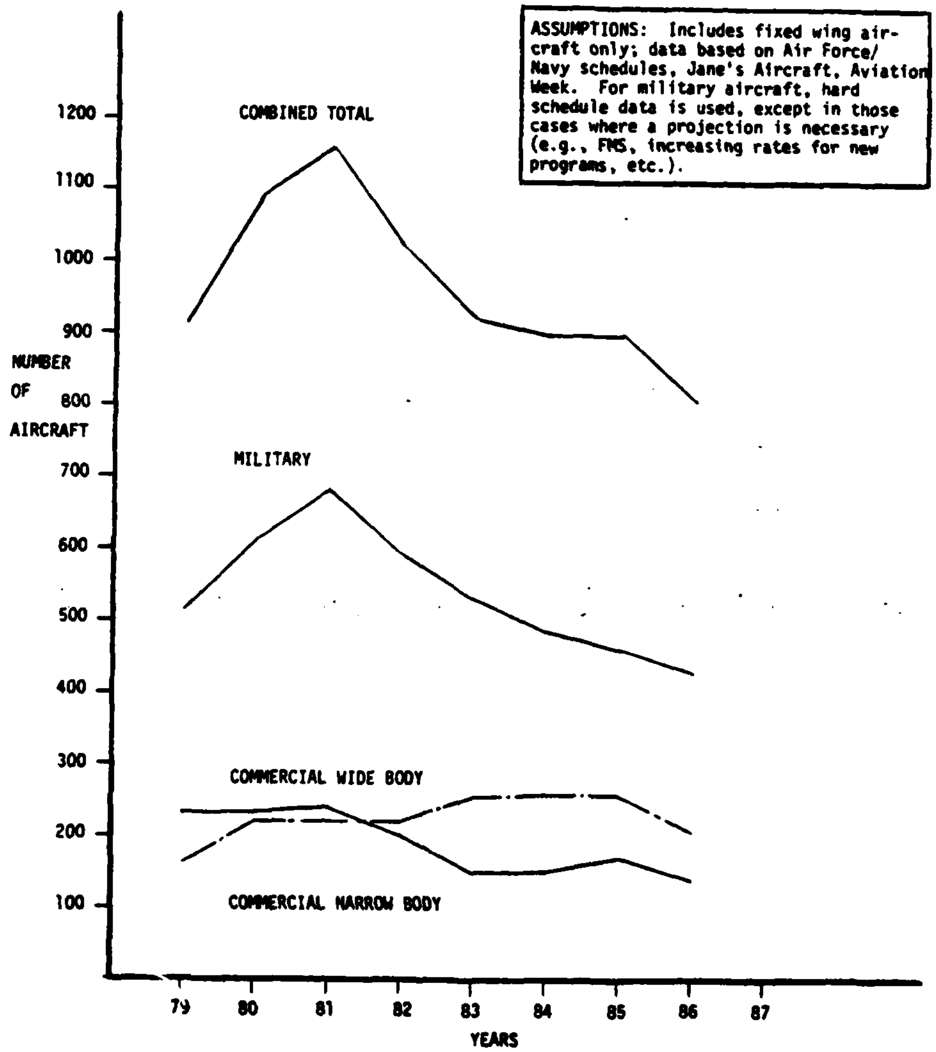

Figure 9. Projected Military, Commercial Aircraft Demand, 1981-1989

large, wide body aircraft is expected to grow from about 200 in 1981 to over 250 during 1983-1985. This will mean increasing materials' requirements for commercial aerospace, even though total aircraft deliveries will remain fairly constant between 1982 and 1985.

Although military demand should begin to decline after 1981, there are new programs which will grow during 1981-85. The CX may begin FSED and initial production in 1981, with first deliveries expected in 1985. The C-5 wing modification will include significant material requirements, as will the KC-135 re-engining program. The Navy's F-18 is a growing program which will probably stay in production through the 1980s. New Air Force programs anticipated for the mid-to-late 1980s are the Next Generation Trainer, the Companion Trainer, and the FX. The combined activity of commerical and military markets will probably hold leadtimes near their current level through the first half of the decade.

Predicting aerospace requirements, 1985 and beyond, entails speculation and guess work. Using the seven year aerospace demand cycle that has been characteristic since the end of World War II, it is reasonable to assume that the commercia' market will begin to decline around 1986. The titanium industry, however, predicts continued growth for its product through 1985. Although this is a leading indicator that aerospace demand could remain strong through the late 1980s, the projections in Figure 9 show total aircraft deliveries declining about 29 percent during 1987-1988 versus 1981-1982. This should lead to a corresponding decrease in materials/components leadtimes beginning in late 1984 or early 1985. It is impossible to predict whether leadtimes will decrease in direct proportion to reductions in aircraft deliveries. Factors such as vendor capacity expansion, materials availability and growth of non-aerospace markets will continue to affect leadtimes after 1985.

Regardless of overall aerospace demand and actual leadtime reductions, the LRCA will probably face fewer materials/leadtimes problems if a Milestone II decision is made in 1985, for the following reasons:

(1) After a 2-3 year Validation Phase, the system and its materials' requirements will be better defined,

(2) More time can be spent considering materials options and alternatives,

(3) There will be a greater opportunity to implement manufacturing technologies which can lead to reduced materials consumption, and

(4) Any capacity expansion by materials processors, forging houses, etc., will have come on-stream.

b. Current/Projected Leadtimes. The primary causes of lengthening leadtimes for aircraft programs are problems with major subsystems (engines, avionics, etc.), and key components/shapes (forgings,

electronics components, extrusions, etc.). The following are current and projected materials leadtimes (Table 6) for those subsystems, components and shapes which are and should continue to be pacing items for aircraft programs. The current leadtimes are based on the Joint Aeronautical Materials Activity (JAMAC) consolidated report of major aerospace contractors' leadtimes, data presented by General Slay at the Corona South meetings, and information provided by ASD program offices and their contractors. The 1981 projections are predicated on a strong aerospace market through 1985. The 1985 projections are based on the anticipated reduction in total aircraft deliveries depicted in Figure 9, page 28.

TABLE 6. MATERIALS LEADTIMES

MAJOR SUBSYSTEMS	CURRENT LEADTIME (Months)	PROJECTED 4th Qtr 1981	PROJECTED 4th Qtr 1985
Engine	36-40	36-40	31-34
Landing Gear	49	49	42
Avionics	24-30	24-30	18-23
Wheels/Brakes	24	24	20
KEY COMPONENTS/SHAPES			
Forgings			
Aluminum (small)	21	21	15
Aluminum (large)	24	24	17
Titanium (small)	30	30	21
Titanium (large)	30	30	21
Steel Alloy (large)	23	23	16
Extrusions			
Aluminum (light)	17	17	12
Aluminum (heavy)	20	20	14
Titanium (all)	20	20	14
Plate			
Aluminum	18	18	13
Titanium	22	22	15
Sheet			
Aluminum	15	15	11
Titanium	21	21	15
Electronic Components			
Connectors	12	12	*
Integrated Circuits	11	11	*
Relays	11	11	*
Fasteners			
Alloy Steel	15	15	11
Stainless	16	16	11
Titanium	18	18	13

* The diverse electronics market makes it difficult to project the correlation between electronics components leadtimes and aerospace deliveries.

Some of the leadtimes for components and shapes could decline more than the 1985 projections indicate. Titanium forgings, for example, are currently affected by both the overall leadtime for forgings and problems of material availability. By 1985, as the material becomes more plentiful, the leadtimes for titanium forgings could be comparable to leadtimes for aluminum and steel forgings.

c. Critical/Strategic Materials. Strategic materials are defined as those which we need for which we are import dependent. The supply of these materials can be jeopardized by unpredictable political changes in third world countries. They are also candidates for OPEC-style cartel actions. Cobalt, tantalum, chromium, and columbium are all strategic materials. Critical materials are essential to defense programs, but import dependency is not the primary problem. Economics and domestic industrial capacity are the principal causes of critical materials shortfalls. Titanium is a critical material, as is aerospace grade aluminum.

Pratt & Whitney has developed an index citing critical/strategic materials risk through 1985. The index is well suited to any new program planned for the 1980s.

MATERIAL	POLITICAL RISK	SUPPLY/DEMAND RISK
Aluminum	Low	Moderate
Cobalt	High	High
Columbium	Moderate	Moderate
Chromium	Moderate	Low
Nickel	Low	Low
Tantalum	High	High
Titanium	Low	High

The following is a more detailed look at each of these materials:

Aluminum - The domestic industry is virtually at capacity for aerospace products. In a recent briefing to the CX program office, Boeing stated that ALCOA has allocated all of its capacity for 1980 and 1981, with final allocations for 1982 to be made later this year. Heavy forgings and extrusions will remain tight through 1985.

Cobalt - The US currently is 97 percent import de-dependent for cobalt. Zaire and Zambia furnish nearly 70 percent of the world's supply. Dramatic price increases followed the rebel invasions of Zaire's Shaba province in May 1978. Producer prices jumped from $6 to $25 per pound, while spot prices went as high as $50 per pound. The situation has stabilized in recent months, with the prices leveling in the $20 to $25 range. Cobalt is highly unpredictable, however, and could unexpectedly become a problem at any time, with shortages and extreme price escalation.

Columbium - Brazil has over 80 percent of the world's Columbium reserves. The material is an important ingredient in super alloys. Columbium prices increased 73 percent - from $3.18 per pound to $5.50 per pound - from 1978 to 1979. There have been no availability problems, and none are anticipated, but prices could continue to rise.

Chromium - The US depends on South Africa, Rhodesia and the USSR for 92 percent of its chromium. Prices have remained surprisingly stable since 1976 and availability has not been a problem. However, the potential exists for serious supply disruptions with chromium, just as with cobalt and other materials from southern Africa.

Nickel - The US gets most of its nickel from Canada and Australia. It is a low risk, but essential material which has remained inexpensive. Prices are now expected to rise from the 1979 level to $2.41 per pound to perhaps as much as $3.50.

Tantalum - There is actually a worldwide physical shortage of tantalum. Limited resources are known to exist; after these reserves are exploited the supply virtually ceases. The price of a pound of tantalum increased from $18 to $75 between 1975 and 1979 - a jump of over 300 percent. Current spot prices are as high as $130. Tantalum is essential to some super alloys and for certain electronics applications. Compounding the problem is the fact that most of the world's remaining tantalum reserves are in politically unstable Zaire and Indonesia.

Titanium - Domestic titanium sponge capacity is outstripped by US demand, and a shortfall is expected for 1980. After that, the supply situation should ease. A major titanium consuming program, such as the B-1

or a titanium hulled submarine, would immediately create shortfalls. Barring such major undertakings, supplies should be sufficient to meet demand through the rest of the 1980s. Prices are currently approximately $4 per pound for domestic sponge, ranging as high as $8.70 for imported material.

d. Industrial Capacity. The leadtime and materials data presented so far pinpoint the major problems with industrial capacity in the US. To reiterate, the basic problem is not so much at the prime airframe/engine contractor level, but in the subcontractor structure. Raw and intermediate materials and processing, forgings, fasteners, bearings, and electronics components are being produced at or near their producers' capacities. Some capacity expansion is anticipated (e.g., the titanium industry will add about 25 percent to its sponge capability between 1981 and 1985), but overall capacity within the aerospace subcontractor base will probably continue below demand through 1985.

Aerospace prime contractors appear to have sufficient capacity to meet the demands of a major new program. Currently, their primary constraint is in the area of skilled labor. In a 22 February 1980 letter, the F-16 Program Office reported that "manpower in skilled areas (e.g., machinists, tool designers, etc.) is not readily available for even attainment of peacetime deliveries." Airframe and engine producers are competing nationwide for skilled personnel and the labor situation should remain tight at least through 1985.

3. Schedule Considerations/Constraints. The projected 1981 and 1985 FSED milestones allow for numerous schedule possibilities and combinations. Anticipated leadtimes, funding considerations, priority ratings and levels of concurrency all affect the ultimate IOC date. Figures 10 through 14 are schedules based on these considerations. The rationale behind each schedule and its advantages and disadvantages are outlined below:

a. Figure 10. This schedule is based on FSED beginning in December 1981, and it follows a fly-before-buy acquisition strategy. It anticipates a leadtime situation very similar to that encountered today. The main landing gear is the longest lead item at 49 months, followed by the engine at 40 months. Additional long lead funding for other materials and components is necessary 30 months prior to fabrication. All RDT&E aircraft are built prior to start of production. Total leadtime for the first production aircraft is 56 months, with fabrication, assembly and test requiring 23 months. IOC takes place on 1 October 1989.

Advantages	Disadvantages
1. Minimum retrofit requirements	1. A two-year production gap, resulting in: - Impact on subcontractor structure - Lost learning
2. Maximum planning opportunities	
3. Optimum number of Production Readiness Reviews (PRRs)	

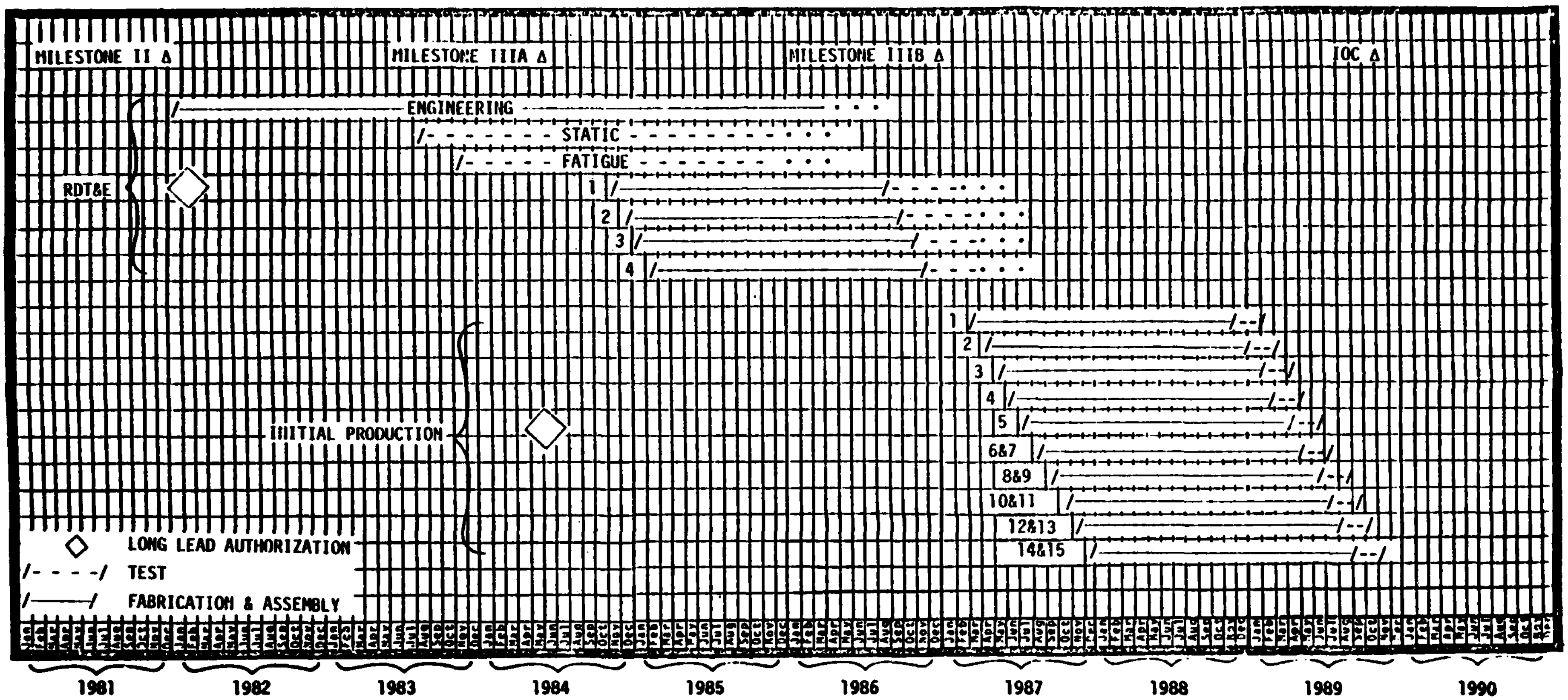

Figure 10. Fly-Before-Buy - Milestone II - 1981

Advantages (Continued)	Disadvantages (Continued)
4. Sufficient testing period	2. Later IOC date
5. No DX priority required	3. Increased cost
6. Time for production tooling design and fabrication	
7. Good opportunity to implement manufacturing technology (MANTECH) and to consider producibility	

b. Figure 11. This figure shows all of the leadtimes found in Figure 10, but proposes a DX rating or long lead funding prior to award of the FSED contract to meet a very compressed schedule. Maximum concurrency takes place to achieve an IOC of 1 March 1987.

Advantages	Disadvantages
1. Earlier IOC date	1. Extensive retrofit
2. Sustain work force	2. Limited planning opportunity
3. No production gap	3. No test results prior to production
	4. High risk areas: - Meeting labor requirements - Cost - Schedule - Performance - Materials
	5. Very limited MANTECH opportunities

c. Figure 12. This schedule also has FSED in December 1981, and it too requires a DX rating or long lead funding prior to FSED contract award. This funding, however, is only necessary for the RDT&E aircraft. Long lead funding for production comes after FSED contract award. The schedule calls for less concurrency than Figure 11, but avoids the lengthy production gap found in Figure 10.

Advantages	Disadvantages
1. Stable work force	1. Later IOC date (than Figure 11)
2. Minimum retrofit of production aircraft	2. No test results before production of first 15 aircraft begins.

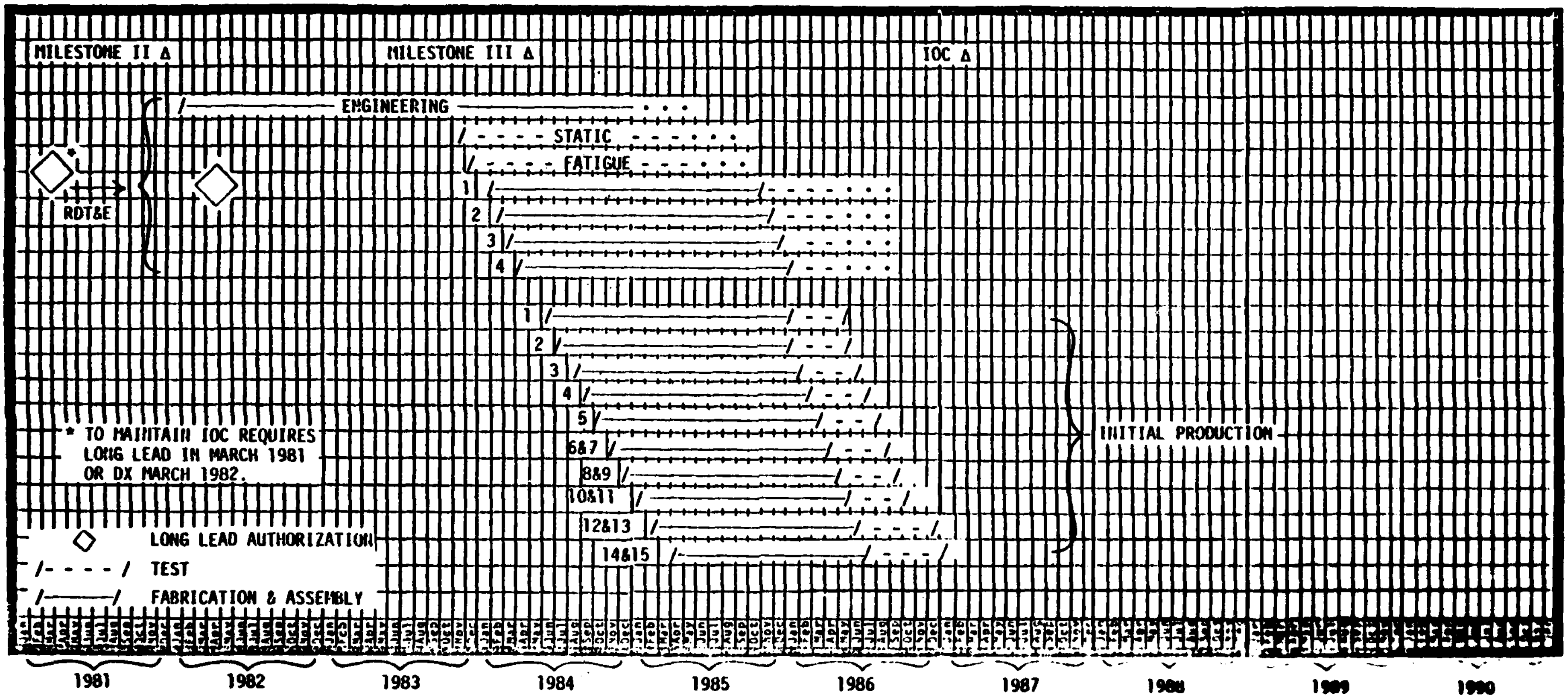

Figure 11. Maximum Concurrency and DX Priority or Long Lead Funding - Milestone II - 1981

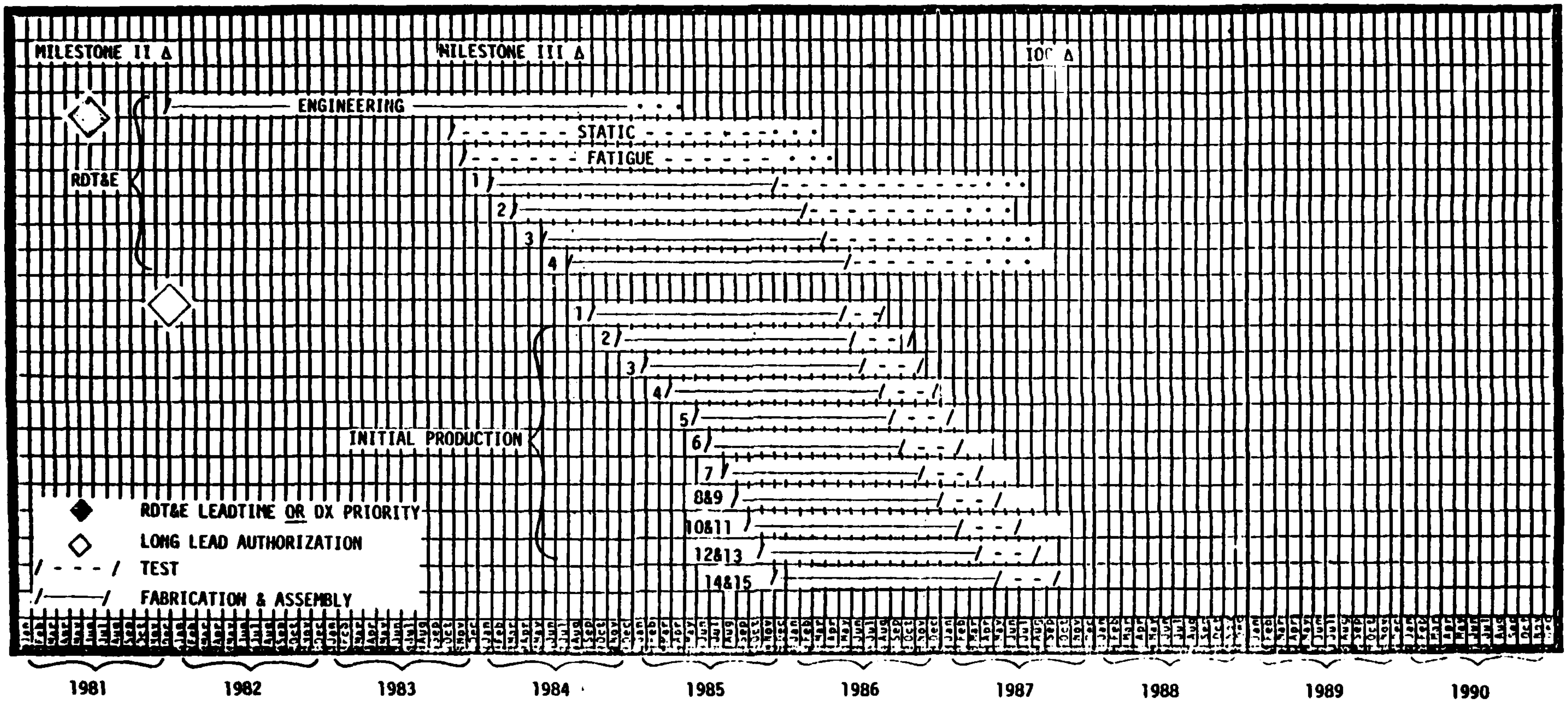

Figure 12. Concurrency with DX Priority or Long Lead for RDT&E - Milestone II - 1981

Advantages (Continued)

3. Slow build-up schedule

4. No production gap

5. Some MANTECH opportunities

Disadvantages (Continued)

d. Figure 13. This schedule is based on an FSED contract award in 1985 and follows the same fly-before-buy strategy shown in Figure 10. It anticipates that the leadtime for the main landing gear will decrease from 40 to 42 months and from 40 to 34 months for the F101 engine. Total leadtime for the first production aircraft is 49 months, with fabrication, assembly and test requiring 23 months. IOC takes place on 1 November 1992.

Advantages

1. Minimum retrofit requirements

2. Maximum planning opportunities

3. No DX rating required

4. Sufficient testing period

5. Limited materials problems

6. Despite four-year difference between 1981 and 1985 FSED, IOC is moved back only three years.

7. Time for production tooling design and fabrication

8. Good opportunity to implement MANTECH and consider producibility

Disadvantages

1. Two-year production gap:
   - Unstable workforce
   - Impact on subcontractor structure
   - Lost learning

2. Increased cost

3. IOC not until 1992

e. Figure 14. This schedule based on 1985 FSED, follows the same pattern of "rational" concurrency shown in Figure 12. Leadtimes are the same as those in Figure 13. IOC takes place on 1 May 1992.

Advantages

1. Stable workforce

2. Minimum retrofit of production aircraft

3. Limited materials problems

Disadvantages

1. No test results before production of first 15 aircraft begins

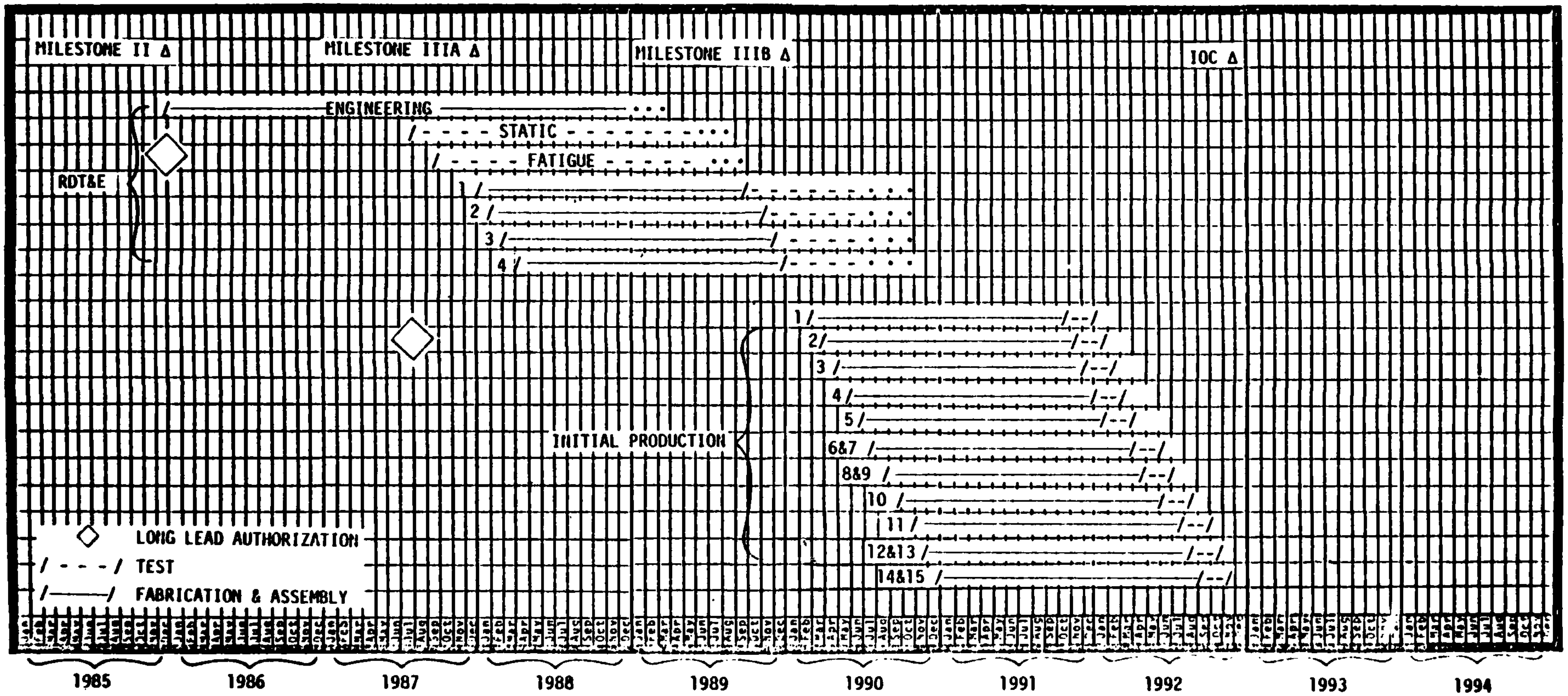

Figure 13. Fly-Before-Buy - Milestone II - 1985

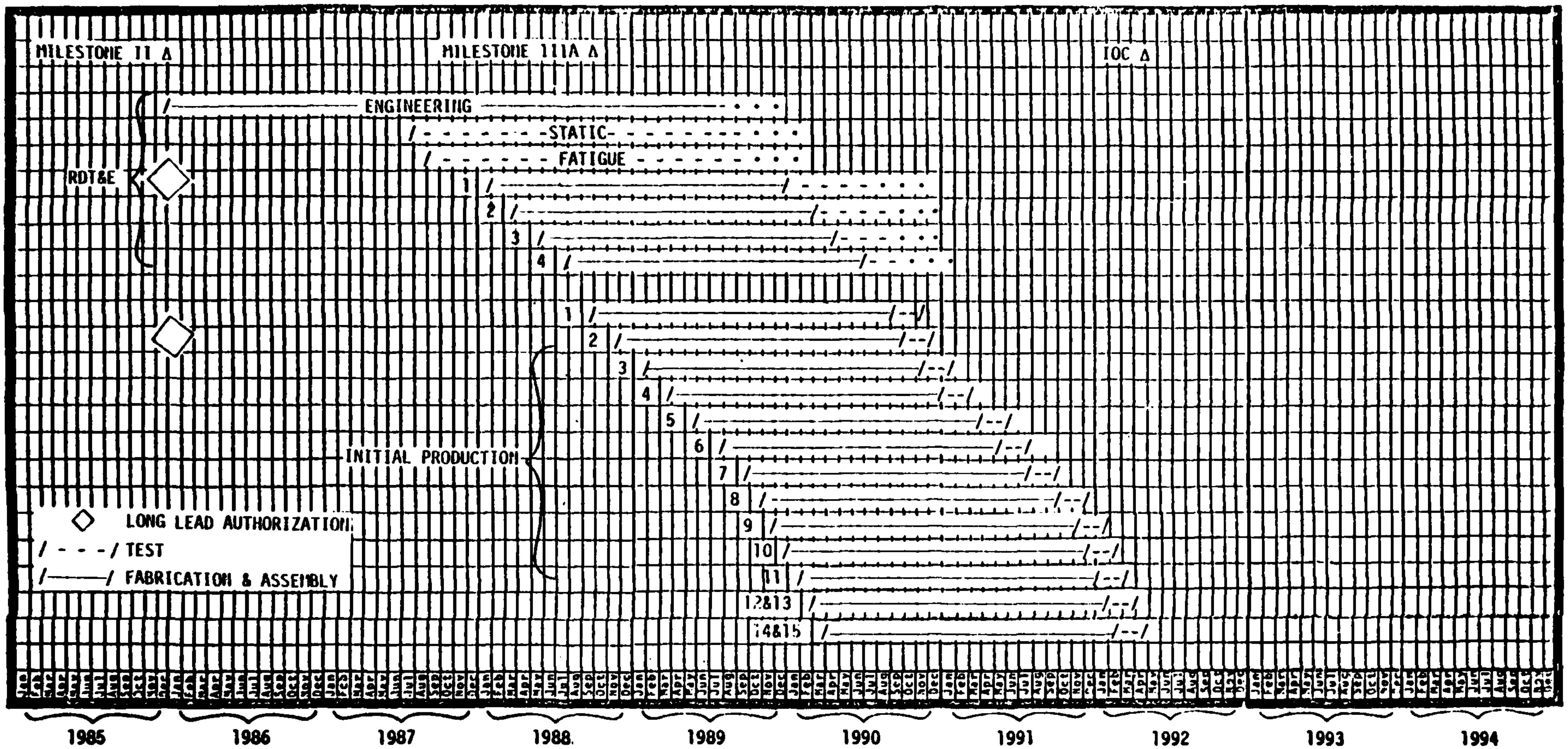

Figure 14. Moderate Concurrency - Milestone II - 1985

Advantages (Continued)	Disadvantages (Continued)
4. Slow build-up rate	
5. No production gap	
6. Good MANTECH opportunities	

4. Detailed Programs. Two detailed schedules (Figures 15 and 16) were generated to support the effort to spread the costs in the Affordability discussion, Section III, Figures 4 and 5 (pages 18 and 19). These schedules employed the rational concurrency discussed above and a low rate production of both the RDT&E units and the 'limited' production units. This low rate production and consequent slow build-up of production is intended to lower the risk of the Milestone II decision and enable the accomplishment of an extensive amount of flight testing prior to the Milestone III production decision. The appropriate material leadtimes were factored into these schedules to support the development of the required funding profiles.

5. Impact of a DX Rating. The positive benefits of a DX rating are undeniable. Boeing estimates that DX rating will reduce the leadtime for the CX landing gear from 49 months to 32 months. This estimate was used in developing the schedules in Figures 11 and 12. In addition to reducing the leadtimes for critical materials, components and subsystems, a DX rating eliminates much of the necessity for specific long lead funding. Further, a DX rating gives a program preferential treatment for obtaining use of military support equipment, test equipment and facilities.

The maximum benefits of a DX rating would probably occur if the LRCA entered FSED during 1981. During that period of high demand and continuing long leadtimes, a DX rating would be essential to meeting a tight schedule (e.g., IOC in March 1987). However, several new programs, including the XM-1 tank, the MX and Pershing II missiles have recently been granted DX status; and the rating is being sought for the CX. The LRCA will require a very strong case as a system essential to national security if yet another program is to achieve a DX rating in the immediate future.

A DX rating for the LRCA might be more likely in 1985, but since pressure in the marketplace should be lessened, results will be less dramatic. It is conceivable though, that the Fiqure 14 schedule (rational concurrency) could be improved to achieve IOC in mid- to late-1991 with a DX rating.

6. Summary.

The narrative in this subsection, coupled with the schedules depicted in Figures 10 through 16 indicate the problems and possibilities of both a 1981 and a 1985 FSED decision. The overall trend in leadtimes should decline by 1985, and competition for some materials will be less intense. This is not to imply, however, that the materials and leadtimes problems in 1981 will be insurmountable. Figures 10 through 12 indicate that with proper planning, and a good understanding of leadtimes, it is possible to make an IOC 6 to 8 years after a 1981 FSED decision. FSED in 1981 would have some impact on the marketplace, but if planning sufficiently

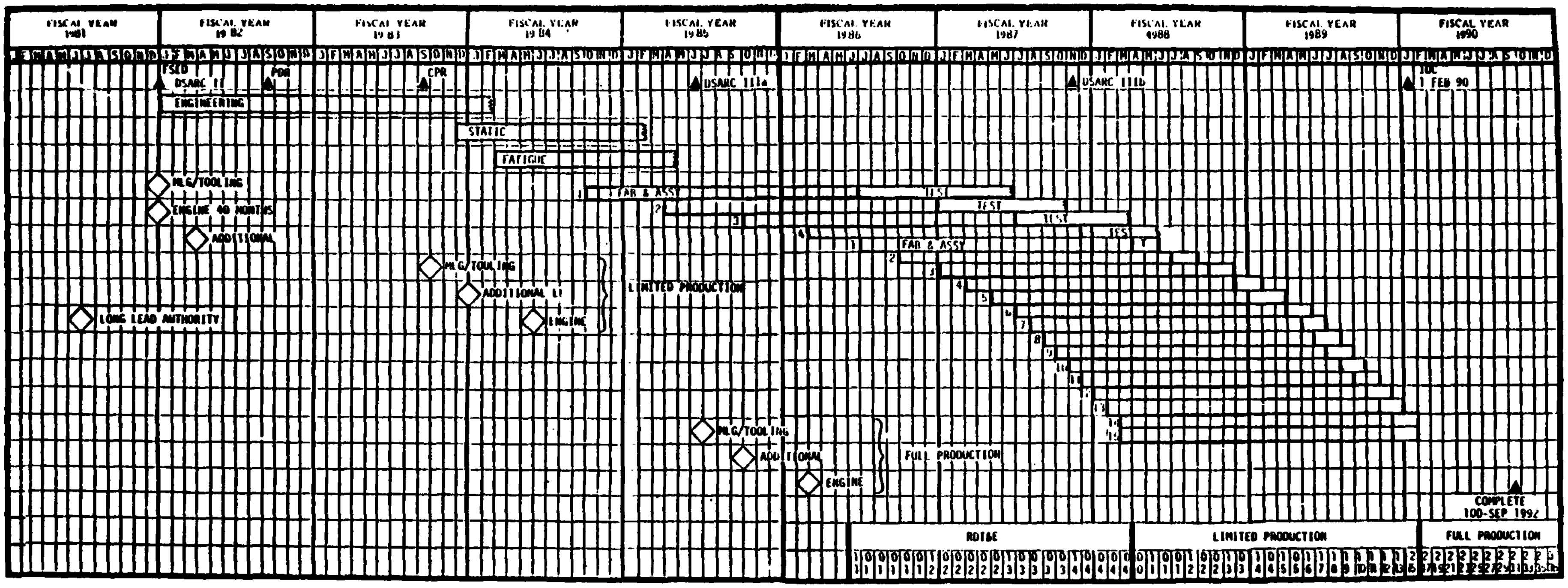

Figure 15. Milestone II - 1981, Rational Concurrency

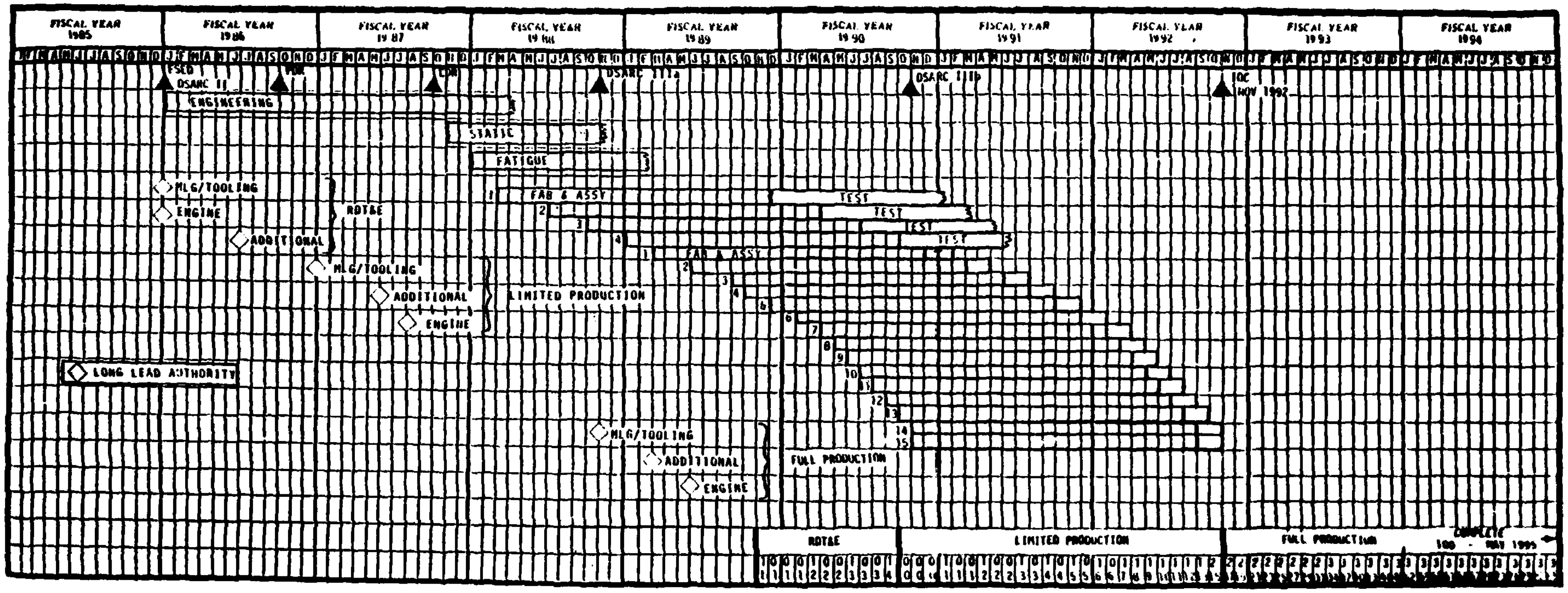

Figure 16. Milestone II - 1985, Rational Concurrency

allows for long leadtimes, such impact can be minimized. It might be less difficult to build the LRCA beginning in 1985, but if the need for such an aircraft exists sooner, its materials/leadtimes problems can be overcome.

C. MANTECH/MODERNIZATION

1. Introduction

For the past 15 years, the US industry has had a decreasing rate of growth in productivity. During this period of time the growth rate has been significantly less than all of the major free world industrial countries as shown in the following:

PRODUCTIVITY GROWTH TRENDS

COUNTRY	AVERAGE ANNUAL GROWTH (%)*
Japan	8.1
France	5.5
W. Germany	5.4
Italy	5.3
Canada	3.7
G. Britain	2.9
USA	2.1

* 1965 - 1977, US Department of Labor

In 1979, the growth rate was negative; that is, productivity actually decreased. The result is that our leadership in many key aerospace technologies is being threatened and our ability to defend our national interests and respond to an international crisis is being challenged.

General Slay, Commander, AFSC has strongly supported an effort to reverse this trend through the application of new technology and plant equipment modernization. We are actively supporting this effort at the AFSC level through the Manufacturing Technology Investment Strategy (MTIS) efforts, as well as, our own efforts to institutionalize our interface with the Air Force Wright Aeronautical Materials Laboratory, Manufacturing Technology Division (AFWAL/MLT). This is being accomplished through the issuance of an ASD Regulation, ASDR 800- 4, "Manufacturing Technology/Modernization." It requires bidders to consider the application of new Manufacturing Technology/Modernization opportunities on any new major ASD acquisition. It also provides for the possibility of Government incentives where and when deemed necessary in the best interests of the Government.

2. Contracting Considerations

A major deterrent to the application of MANTECH/Modernization is an early IOC date and/or concurrency of the conceptual/validation/FSED phases. The following figure shows an idealized system acquisition process:

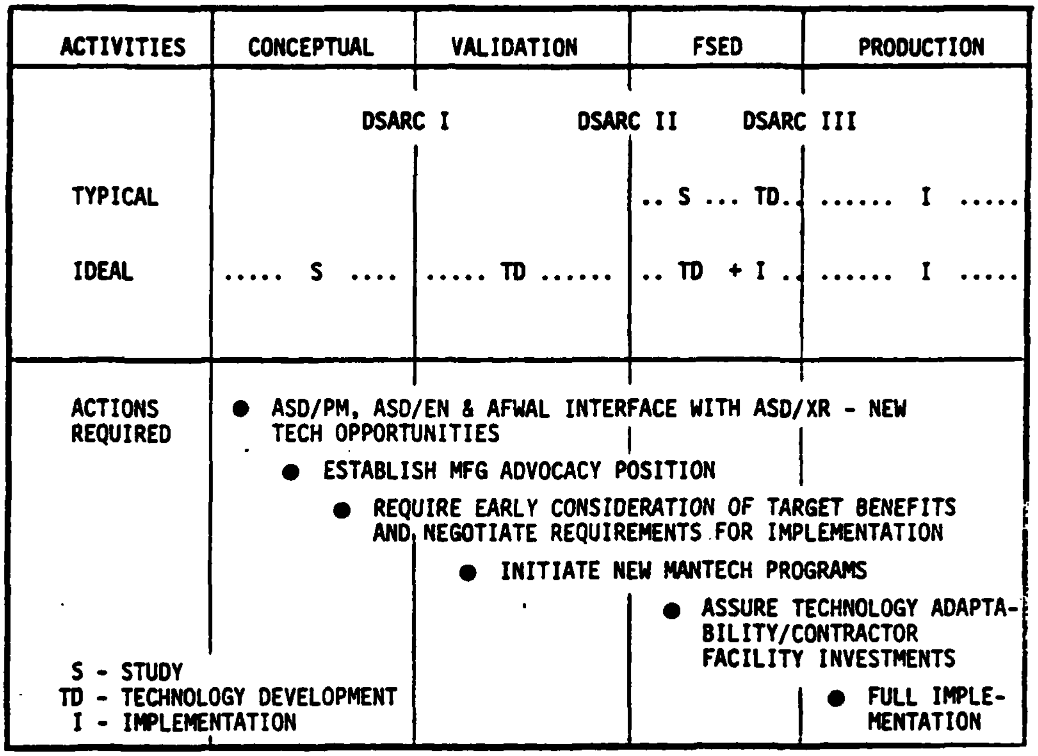

Figure 17. MANTECH/Modernization Application in the Systems Acquisition Process

As indicated, each phase should be conducted in sequence, building on the results of prior effort. However, the usual circumstance is that the conceptual/validation phases are eliminated, shortened, or conducted concurrently with FSED. The consequence of this is that MANTECH/Modernization efforts are severely constrained, as shown, and in most instances cannot be established in time to influence design decisions for maximum productivity/producibility. Some opportunities do get established in time to be applied during production; however, their productivity enhancement potential is limited. Productivity improvement potential is greatest when the acquisition cycle is normal (no concurrency), and MANTECH/Modernization is given full consideration during the conceptual/validation phases as indicated. Reasons for this include:

a. New manufacturing methods and/or processes can influence design for maximum benefit. For example, the use of cast aluminum for

primary structure applications such as pressure bulkheads or wing ribs requires redesign for mechanical property differences. Castings in lieu of conventional rib or web structures offer the designer the unique design opportunities to maximize structural efficiency. This is possible because of the unique manufacturing capability of the casting process over conventional structure.

b. The manufacturing capability including facilities and qualified sources must be planned for and, if required, new process development/improvements accomplished prior to production commitments. These tasks take time and resources to accomplish. If either is in short supply, the opportunity window may be missed. Thus, the early consideration of MANTECH/Modernization is vital to maximize application and productivity enhancement potential.

The near term DSARC II date of December 1981 for LRCA creates a limited opportunity situation. Unless the MANTECH/Modernization concept can be readily incorporated into the design (i.e., direct substitution), and the required manufacturing capability (including planning, facilities, trained personnel, and experience) exists or can be obtained during FSED, many opportunities will be missed, which could have otherwise been considered. Nevertheless, there are many opportunities which can be incorporated with the early DSARC II date and can be considered even into the production phase, but with accordingly less advantage. These opportunities would have to be considered on the basis of direct tradeoff studies and without the advantage of design change benefits.

On the other hand, the longer term DSARC II date allows time for consideration of existing and near term MANTECH/Modernization opportunities as well as new opportunities which, if given sufficient emphasis during the early phases, could be ready for production implementation.

3. MANTECH Opportunities

Table 7 is a listing of new manufacturing technology opportunities for potential application on LRCA. It is not a detailed list and should not be construed as such. However, it does identify the major new manufacturing technology opportunities being established at the present time which could impact a new system. Each opportunity listed implies a base line of corporate knowledge to successfully apply such as engineering and manufacturing "know how", available or attainable facilities for utilization, and a qualified industry base (preferably two or more sources) to supply equipment, facilities or products required.

The list is split our by application area (i.e., airframe, engine, avionics) and availability (DSARC II dates). Additionally, several new emerging, as well as currently available technologies, are further identified as having potential for application or extended application, respectively, at the later DSARC II date if given additional emphasis in the near term. These constitute sufficient ROI potential to be worthy of consideration for a technology modernization effort such as the F-16 technology/modernization effort currently in progress. Some of these technology opportunities bear some additional discussion. The AFWAL/ML ICAM effort will, over the next few years, revolutionize the aerospace

TABLE 7. NEW MANUFACTURING TECHNOLOGY OPPORTUNITIES FOR LRCA

TECHNOLOGY	OSARC II DEC 81	OSARC II 4TH QTR 85	TECHNOLOGY MODIFICATION OPPORTUNITY	LIFE CYCLE COST
AIRFRAME/ENGINE - Adv Composites				
Secondary	X			+
Primary		X	X	+
ICAM	X		X	
Superplastic Forming/ Diffusion Bonding of Titanium	X			+
Relaxed Tolerances	X			
Adv Machining	X		X	
New Titanium Alloys		X	X	+
Auto Wire Harnessing	X		X	
Adv NDI	X		X	
Powder Metallurgy Titanium		X	X	
Castings in Titanium	X(ENG)	X(AIR)	X	
Photogrammetry	X			
Auto Assy Fixture Drill	X			
AIRFRAME ONLY - Bonded Aluminum				
Secondary	X			
Primary		X	X	+
New Aluminum Alloys		X	X	+
Weld Bonding	X			+
Bonded Fuel Tanks	X			
Cast Aluminum	X	X	X	
7050 Rivets	X			
Powder Aluminum Alloys		X	X	+
ENGINES ONLY - Segmented Mold Castings	X		X	
D.S. and D.S.E. Alloys		X		+
Mono Crystal Blades		X		+
New Superalloys		X	X	+
High Speed Bearings		X		+
Ceramic Applications		X	X	+
RSR Powder Metallurgy		X	X	+
Adv PM Processing	X	X	X	
Critical Materials Conserv	X	X	X	
Joining/Fabrication Repair	X	X	X	
Dual Property Disks		X	X	+
Bore Entry Disks		X	X	+
Seals	X	X	X	+
Ring Rolling	X		X	
Coating Technology	X	X	X	
AVIONICS - High Voltage Supplies	X			
Processing Silicon ICs	X			
Polyimide PCBS	X			
Full Wafer LSI Modules	X			
Silicon Devices on Insulative Substrates	X			
CCD Memory Arrays	X			
Adv Insp of LSI Circuits	X			
Low Cost Chip Carriers		X	X	
Conformal Coatings	X			
Logic Arrays	X			
Ferrite Phasers	X	X	X	
MNOS Memory Arrays	X	X	X	
Adv Signal Processing	X	X	X	
Phasers & Phase Cotnrol Modules	X	X	X	
TWT Technology	X	X	X	
FLIR Adv Mfg Method	X	X	X	

industry across the full spectrum of manufacturing processes industry direct (unit processes) and indirect (manufacturing systems, management and control).

Computer technology is already becoming heavily infused into the aerospace industry for design, management and manufacturing. For example, Boeing, Seattle, has 57 separate computer control systems on line, all of which can communicate with each other for integrated design, management and production. They are currently in the process of adding an additional 24 systems as a part of their current extensive capital investment program.

New ICAM innovations will result in fully integrated manufacturing centers such as machining, sheet metal, and electric bench which, in turn, will fully integrate into a total factory concept. Thus, the factory will be integrated from initial conceptual design, to detail design, manufacturing (including the materials handling) and final parts inspection. Tying this together will be integrated management information systems for the control.

An additional area that ICAM will contribute productivity gains to is materials handling. This has been a traditionally difficult area to improve productivity in the aerospace industry because of the wide variety of materials, cumbersome size and shape of parts and subassemblies, protective requirements and low volume. Extensive use of computers for applications such as materials storage and retrieval, automated paint and process lines, manufacturing cell and center concepts are all keyed to improved materials handling. The benefit of this technology alone could reduce direct manufacturing costs by five percent or more.

Current Air Force aircraft have less than two percent composite structures. However, with application potential extending from secondary structure to primary structure, large aircraft such as LRCA may have application for up to 25 percent composite structure. The manufacturing process for composites are amenable to ICAM technology. Significant productivity advances will be made as these technologies blend.

Metal removal, primarily machining, is a major cost center for any new systems acquisition. Typically, machined airframe and engine components have buy-to-fly ratios of 7-1 and 30 percent to 59 percent of the cost of the part is in machining the excess material away (usually critical/strategic material which gets lost to the industry through poor scrap management). Advanced N/C machine tools are available today which significantly reduce machining time. The problem is, however, productive use of the machine. Typical machine usage time is 30 percent or less. Innovative use of the ICAM cell-center concepts, and materials handling methods can improve machine usage time to greater than 80 percent and reduce costs by more than 50 percent. This technology will impact LRCA, the extent to which depends on how rapidly the new innovations are transitioned to the production floor.

Additional key technology opportunities with significant productivity improvements are primary adhesive bonded aluminum structures (PABST)

and powder aluminum for airframes, segmented mold castings, new alloys and processes (DS, DSE, monocrystal), advanced powder metallurgy processing, joining/fabrication technology and advanced repair concepts for engines, and MNOS memory arrays, advanced signal processing, traveling wave tube (TWT) technology, phasers and phase control modules and FLIR advanced manufacturing methods for avionics applications.

4. Cost Benefits

A number of studies conducted by the Air Force and industry have shown that direct manufacturing costs constitute no more than about forty percent of the acquisition cost of a system. Furthermore, it has been estimated that the maximum benefit of new manufacturing technology opportunities, such as those shown on the Table 7, page 47, is on the order of 40 to 50 percent cost avoidance. Assuming these estimates are reasonable, the application of new manufacturing methods technology could reduce acquisition costs by 15 to 20 percent. The remaining 60 percent is in indirect overhead costs such as management, material control, planning facilities, etc. It is estimated that near-term opportunities through ICAM (primarily) can reduce those costs by as much as 15 to 20 percent. Longer term benefits can be as much as 50 percent for acquisition cost reduction potential of 10 to 15 percent near-term, 30 percent long term. This is depicted in the following Figure 18.

	MILESTONE II 1981	MILESTONE II 1985
• DIRECT (30 - 40%)	15 - 20%	30 - 40%
• OVERHEAD (60 - 70%)	15 - 20%	40 - 50%
TOTAL	15%	30%

Figure 18. Potential MANTECH Cost Benefits

Finally, life cycle costs (LCC) are affected whenever new manufacturing methods, processes and materials are used. The technology areas listed have been assessed as to whether they would have a positive or negative affect on O&S costs as indicated on the Table 7, page 47. Any further cost avoidance potential would be difficult to assess at this point.

5. Summary

For maximum productivity/producibility benefit of MANTECH/Modernization, it is recommended the fourth quarter 1985 DSARC II date be adopted.

Additionally, rational concurrency is recommended so that design options can be considered in the application of new MANTECH opportunities for maximum benefit.

Finally, a MANTECH/Modernization requirement should be included in the RFP per the guidance of ASDR 800-4 and recent ASD efforts.

Implementation of MANTECH/Modernization could significantly affect program affordability.

D. MUNITIONS

A major consideration affecting LRCA availability is the complement of weapons which are available to support it. In support of this effort a survey of both the conventional and nuclear weapons currently available and planned was taken. Since information regarding the specific types and quantities of munitions is classified, they are not included in this report. Review of these data support the conclusion that parallel weapons development efforts are necessary to provide an acceptable level of LRCA effectiveness.

E. AVIONICS

The design requirements for LRCA are currently not specified, however, are anticipated to be consistent with the general statement of requirements contained in the "USAF Scientific Advisory Board Summer Study of the Long Range Combat Aircraft" task statement. It provides that the LRCA ". . . must be able to fly long distances, to carry large diversified payloads, to provide self-contained capability for target acquisition and weapons delivery, to defend itself against sophisticated air defenses, and most importantly, to provide on-the-scene, human judgment throughout the mission." The implications of this generalized statement include:

- Worldwide navigation and communications;

- Sophisticated stores management accommodating large quantities of both conventional and nuclear direct attack and standoff weapons;

- Diverse on-board sensors with capability to detect, locate and classify a spectrum of targets combined with an interface to the intelligence network;

- Precise navigation for initialization of weapons and interface with various weapons guidance schemes;

- Defensive capability both lethal and nonlethal to include threat detection, classification and warning, fire control, electronic countermeasures, and possibly expendables; and

- Intelligence gathering and processing capability coupled with a worldwide ability to communicate with command authorities.

The precise avionics suit necessary to support these capabilities would have to be defined within the FSED schedule option selected.

Additionally, the avionics core architecture would be developed in either case using various standards. The key standards applicable to a LRCA are:

- MIL-STD-1553B - Multiplex Bus
- MIL-STD-1589A - Higher Order Language
- MIL-STD-1750A - Computer Instruction Sets

The avionics considerations for the alternative schedule considered are:

1. Milestone II - 1981. The approach under this schedule would be to use previously defined B-1 and B-52 Offensive Avionics System hardware elements as a point of departure for hardware and architecture with provisions to subsequently evolve, as necessary, to reach the changing threat. The primary risk in this alternative would be that of schedule which currently provides less than 18 months to define requirements, request proposals and make the FSED award.

2. Milestone II - 1985. This schedule would enable a more ordered program to include development of the architecture requirements during the conceptual phase and the demonstration and validation of the performance of key elements of the system prior to the FSED award. This would significantly reduce the Milestone II risk.

Regardless of the schedule followed, the selection of equipment to fulfill the LRCA avionics requirements will be within the constraints imposed by AFR 800-22 and AFSCR/AFLCR 800-31. These regulations provide the policy, guidance, and strategy for selecting equipment for use on a new system development. Within the overall constraints imposed by the criteria for item selection and acquisition method, equipment will generally be selected according to the following order:

a. Air Force Designated Standard Items/Preferred Items;

b. Items in the Government inventory or being developed under Government contract;

c. Commercially available items that meet technical and logistics requirements;

d. Modifications of any of the above; and

e. New items to be developed.

This order of selection supports the AFSC/AFLC application of the Air Force policy of requiring program managers to maximize the integration of designated standard and preferred equipment into new system developments and providing this equipment to the contractor as GFE.

F. COMPUTER RESOURCES

1. General

The LRCA is likely to experience a higher level of automation than any earlier aircraft. Offensive avionics are likely to interface with smart weapons of a variety of types including possibly beam weapons which will invoke additional computational requirements on the aircraft. Defensive avionics will be required to accommodate a broader variety of threats with more rapid change capability than in the past. The LRCA most likely will require substantial data communication, possibly through satellite relays. Digital flight controls and engine controls will further contribute to expanding the degree of automation. More built-in test and on-board system test and preplanned reconfiguration are likely. As equipments fail, the computer resource system must accommodate these failures. Finally, the integration of controls with other functions such as weapon delivery and beam weapons will further add to the degree of automation.

Computer resources will also be required for ground support systems such as Automatic Test Equipment (ATE) and Aircrew Training Systems (ATS). The expansions of automation in the ATE area are not expected to be as much as that in air vehicle itself. Since more testing will be done aboard the aircraft and since highly integrated circuits are not economically repairable, the demand for automation in ATE will increase at a slower rate than in the air vehicle. The trend in ATS has been toward greater realism; hence, the computer resource requirements are likely to grow at a rate comparable or faster than that of the aircraft.

The higher levels of automation are being driven by the rapid advance in computer hardware technology. Microcomputers will be used in substantial numbers on a LRCA against the earlier schedule. Very High Speed Integrated Circuits (VHSIC) and Very Large Scale Integration (VLSI) are possible for the earlier schedule, but more likely for the later schedule. Radiation considerations will probably require the introduction of fiber-optic data communications and shielding or hardening of critical data processing elements. Magnetic bubble memories and airborne disc systems may find a place in the LRCA for mass storage.

Today's evolving computer resource standards will almost certainly be applicable to the air vehicle. The multiplex data bus standard, MIL-STD-1553, is appropriate for all on-board digital communications except for high data rate/data volume requirements. The

approved JOVIAL J73 language (MIL-STD-1589) for on-board computer programs, ATLAS for automatic test equipment, and FORTRAN for aircrew training systems and support software are all appropriate with ADA, a consideration for the longer schedule. The avionics instruction set architecture standard, MIL-STD-1750, will be appropriate for the integration function aboard the LRCA according to the shorter schedule. For the longer schedule, if available in VHSIC or VLSI, MIL-STD-1750 will be appropriate. Lack of a microcomputer version of MIL-STD-1750 will most likely work against this standard being applied for all 16-bit applications aboard the aircraft for the shorter schedule. Commercially available microcomputers may prove to be more cost-effective where high performance is not required. For potential 32-bit computer requirements, an appropriate standard is not yet available, but may be available by the time of full-scale engineering development.

2. Major Concerns

Two major concerns or risk areas identified for computer resources are complexity and skill shortage. For a distributed system with highly interactive functions, the complexity must increase over less interactive systems. A consistent effort is required to achieve as simple a system as possible and still meet performance and growth requirements. As the complexity and interactiveness increase, a longer time is required for system design, integration and test over previous simpler systems.

A key to simplicity is the nature of the architecture of communication among various automated subsystems. It is likely that multi-tiered, multiplex communication will be one of the design options. Whatever architecture is chosen is likely to be different from what exists in present aircraft. For the shorter scheduled development, this architecture will be a higher risk item. For the longer scheduled program, an opportunity exists to simulate and breadboard several architectures prior to full-scale engineering development. This breadboarding exercise will assist in defining an appropriate architecture and will be very useful in providing experience to contractor staff for the subsequent design, integration and test activity during full-scale engineering development.

The desire to prevent propagation of software errors and hardware faults through the computational system will be more difficult to accomplish as the system becomes more interrelated. Requirements for fault tolerance and redundancy are very likely; however, inadvertent nuclear release or flight safety impairment will still require special consideration in design and test. Independent verification and validation of subsystem design and computer programs will probably be required. Certification of safety will have to be more extensive than on previous programs.

The potential complexity of the system will have impact on Logistic Command support requirements for computer programs. To reduce this requirement an attempt should be made in the architectural design to identify and separate those computer programs whose future modification would not substantially enhance system performance from those programs where modification offers substantial future performance improvement. Such an approach should reduce costs, both during development and operations.

The second important risk area deals with engineering skill shortage in both program office and contractor organizations. Since LRCA will likely be a major program, it will have the leverage to attract competent system and software engineering management. The risk area is in the lower level system and software engineers and subsystem software engineering specialists. System engineers with strong software engineering background will continue to be in short supply. Such specialty areas requiring digital flight control engineers, digital engine control engineers, specialists in new computerized sensors, and particle beam experts with computer resource background will all be in short supply. Another area of risk is a shortage of subcontract managers who have a strong enough computer resource background to assure timely accomplishment of adequate, automated subsystem designs. A partial solution to the skill shortage problem is additional emphasis in the RFP and source selection process on the necessity of these skills in the computer resource area. Such emphasis should bring forth the best talent in each prime and subcontractors' organization.

3. Conclusion

The computer resource elements that are likely to be a part of LRCA will remain a challenge as they have been on current aircraft systems. The longer schedule which permits a formal validation phase will surely reduce the risks associated with computer resource development.

G. SUMMARY

The availability of the LRCA to support an identified need is dependent upon numerous factors. One of the most critical is the leadtime associated with the materials and major components necessary to fabricate the airframe. These leadtimes, while affecting the timeliness of the product, are not insurmountable obstacles to the availability of the aircraft. They do, however, require planning and the availability of long lead funding to ensure that critical components such as engines and major forgings are on-dock to support an ordered fabrication and assembly.

Generally, through planning and management, the LRCA will be available to support the mission need; however, in the absence of a national emergency, the full operational capability will not be fielded prior to the mid-1990s. Additionally, to assure the full potential of the LRCA, it will be necessary to pursue parallel advanced munitions developments.

V. LOGISTICS IMPLICATIONS OF LRCA

A. INTRODUCTION

Logistics considerations for a Long Range Combat Aircraft (LRCA) must begin with operational readiness and affordability. Operational readiness will be influenced by such factors as system reliability and maintainability, availability of trained support personnel, availability of adequate support equipment and materiel, and the support concepts and administrative and distributional framework necessary to integrate all the elements of logistics so as to be responsive to the operational requirement. Each of these factors will in turn directly contribute to the total system life cycle cost, which will govern the affordability of the LRCA system.

To ensure the deployment of an effective, affordable LRCA system, there must be a balance established between required system performance and capability, supportability and life cycle cost, and the time allotted to bring the system into full operation. The nature of this balance will determine the program risk, which relates directly to the probability that the system can be fielded within cost, on schedule, and to specification. Ultimately, both systems' readiness and cost, as well as systems effectiveness, will be driven by systems logistics factors. Therefore, consideration of program risks must include the implications of logistics.

B. LOGISTICS ANALYSIS

To ensure proper consideration of the logistics implications and requirements of a LRCA system, mission analyses studies leading to definition of the operational need and subsequent concept definition studies exploring alternative solutions must include analysis and synthesis of logistics issues as an integral part of those efforts. The key to this is the Logistics Support Analysis (LSA).

The LSA is a systematic, comprehensive analysis conducted on an iterative basis throughout the systems engineering process. The LSA process intermeshes with the traditional engineering efforts and disciplines to identify logistics risks, costs and constraints, and to influence design toward increased readiness and affordability. The LSA evolves with the systems design, beginning with the earliest consideration of need.

A key element of the LSA is the establishment of a consistent data base of design and logistics information for use by all participants in the systems engineering effort as the system evolves. The objective of the LSA is to provide, within the systems engineering process, the ability to achieve a balance between system readiness, operational capability and cost, and logistics support requirements. The LSA process provides the means to achieve this by identifying logistics design requirements, influencing the design process to achieve the requirements,

establishing lines of communication between the engineering disciplines to develop support resources, and providing the baseline data for verifying the system.

C. MAINTENANCE CONCEPT

The logistics system for the LRCA will be dependent on the maintenance concept. The maintenance concept will, in turn, be determined by the operations concept as well as considerations of supportability and affordability. In the early stages of mission analysis, the implications of the system need and alternative system solutions concerning maintenance and the supporting logistics infrastructure must be systematically examined. At this stage, alternative maintenance concepts should be explored in terms of relative impact on readiness and affordability.

Based on current concepts for a LRCA, strong emphasis should be placed on simplicity and durability. The balance between subsystem reliability, maintainability, and rapid on-line fault detection and isolation and the range and complexity of ground-based support and test equipment should be explored. System maintenance requirements should be tailored to avoid the need for unusual maintenance skill levels. Standardization of subsystems and equipment, and support equipment at all levels, must be stressed. Creative systems engineering and materials improvement are needed to minimize maintenance problems due to corrosion and fuel leaks. Trade studies performed to establish requirements for basing, facilities, support equipment, transportation and handling, as well as system operation, must emphasize energy management. Lessons learned indicate that this is an area often little understood and poorly studied which can have immediate and long-term consequences for readiness and life cycle cost. Another area for thorough analysis and concern is the support of computer resources, particularly software.

D. SUPPORTABILITY

Initial mission and systems analyses should be concerned with overall logistics implications of the system's need and alternative solutions in terms of cost, resource requirements and technical reasonableness. These considerations will be recorded to form the single validated data base for design and logistics engineering and evolve into the logistic support analysis record in later phases. Through the LSA process, the separate elements of the logistics system can be defined and integrated to ensure the timely deployment of a supportable system.

In the present environment, a key logistics element that is crucial to supportability is manpower. The implications for each system alternative of the availability of sufficient trained personnel to operate and maintain a LRCA must be considered.

It is also essential to include the time factor in any consideration of supportability and life cycle cost, which in turn, affects readiness. There can be no short cuts taken in the definition and deployment of the logistics elements of the LRCA system without increasing program risk and jeopardizing system operational readiness and suitability. Key milestones for definition, development and demonstration of the logistics

elements, including reliability and maintainability, must be planned and integrated with system development and test milestones to ensure development of a supportable, deployable system.

Finally, it is critically important that the entire system be thoroughly analyzed. This must include the requirements for and capabilities of supporting systems such as tanker aircraft, weapons, etc., and the systems for ensuring their deployment or distribution in the right quantities and types at the right place and time.

E. IMPLICATIONS OF TECHNOLOGY ON LOGISTICS SUPPORT

The supportability and life cycle cost of a LRCA, in addition to its operational effectiveness, will be affected greatly by the technologies selected for application. Program risk will be greatly increased if advanced technologies are forced into application before their supportability and affordability are adequately determined. Alternative solutions should be pursued to ensure technology options are available to meet system performance, cost schedule requirements in the event a particular technology cannot be matured in time. Determination of maturity must include the existence of means of producing and supporting the new technology within acceptable cost and schedule limits.

F. PROPULSION LOGISTICS FACTORS

A major technology area that will influence system effectiveness, readiness, program risk and supportability is the propulsion system. The alternative schedules proposed identify the tasks to reach Milestone II by either 1981 or 1985. These schedules may restrict the options available for propulsion systems since Milestone II requires that propulsion technology demonstration and validation be completed.

The three options for propulsion systems are: existing, in-service systems; derivative systems; and new, advanced design systems. Mission requirements will be a major determinant of the propulsion system requirement. The leadtime available to meet the required operational capability will also be a determining factor. The risk to program cost is readily relatable to logistics implications, which drive not only operation and support costs but development costs as well.

Existing in-service engines could be made available for either the FY 81 or FY 85 Milestone II requirement. The FY 81 Milestone II would preclude an extensive competitive demonstration test program; therefore, the program risk would be defined by the extent to which the engine fits the mission requirements. There is considerable risk of decreasing durability, which would increase logistics costs and impact system availability, if the engine design is not adequately matched to the requirement. Testing programs would have to be designed to identify the degree of design/mission match in a relatively short period to reduce this risk. Conversely, the FY 85 Milestone II would appear to provide sufficient time to perform durability testing on current engines and possibly on engines not yet in service. The program risk of developing a LRCA with an existing engine, depending on the degree of design/mission fit, would be considered low to moderate for the FY 81 milestone and low for the FY 85 milestone.

Derivative engines present a different picture. A derivative engine would still require some level of component testing to accomplish a complete demonstration and validation of technology. However, since the derivative technologies applied should permit the design to match mission requirements, the source of risk is different. The testing requirement has changed from analysis of potential deviation from a known baseline to the validation of modified baseline. The extent of modification is the key issue. To meet an FY 81 Milestone II, little modification from existing engine baselines would be possible without introducing considerable risk that the propulsion system supportability and life cycle cost would be unacceptably impacted. The FY 85 Milestone II, however, provides a greater opportunity for fully demonstrating and validating derivative technology prior to the FSED decision. The risk in a derivative propulsion system, then, would appear to be moderate for the FY 81 milestone, and low to moderate for the FY 85 milestone, depending on the extent to which new technology is incorporated.

New engine development naturally offers the greatest risks to supportability and life cycle cost. New engine development by FY 85 could require technology development programs preceding the propulsion system demonstration and validation. The schedule normally required for this type of effort would have to be compressed even to meet this date. The source of risk here has now moved to validation of a new baseline. A moderate to high risk is apparent since new technologies might be incorporated throughout the design.

A summary of the alternatives and risks is shown in Figure 19.

PROPULSION SYSTEM OPTIONS	MILESTONE II DATA FY 81	FY 85
Existing	Low to Moderate	Low
Derivative	Moderate	Low to Moderate
New Centerline	N/A	Moderate to High

Figure 19. Propulsion Logistics Risk Summary

G. SUMMARY

From the standpoint of logistics, the LRCA acquisition strategy should focus on ensuring the exploration of alternative design and support concepts to derive candidate systems which achieve the required performance at acceptable levels of readiness and life cycle cost. The application of advanced technology to achieve competitive levels of performance must be based on a thorough evaluation and trade-off of performance, development risk and leadtime, and life cycle cost. The total operational system, including the supporting operational and logistics systems, must be considered in defining the system need and alternative solutions.

To provide for future growth of the system, consideration should be given to the concept of Pre-Planned Product Improvement (P^3I) in the definition and selection of system alternatives.

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VI. SALT II IMPLICATIONS

A. The "Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Strategic Offense Arms" signed 18 June 1979 (hereinafter referred to as SALT II) potentially impacts the LRCA program. The Treaty and Protocol provisions which apply to LRCA are discussed below.

1. Subparagraph 3 of Article II of the Treaty provides:

Heavy bombers are considered to be:

> "(a) currently, for the United States of America, bombers of the B-52 and B-1 types . . .; (b) in the future, types of bombers which can carry out the mission of a heavy bomber in a manner similar or superior to that of bombers [of the B-52 and B-1 types] . . .; (c) types of bombers equipped for cruise missiles capable of a range in excess of 600 kilometers; and (d) types of bombers equipped for [air-to-surface ballistic missiles (ASBMs) capable of a range in excess of 600 kilometers]."

The associated First Agreed Statement defines the term "bombers" to mean " . . . airplanes of types initially constructed to be equipped for bombs or missiles." Consequently, if the LRCA is constructed to be so equipped it would fall within the scope of the Treaty. Furthermore, if the LRCA were designed to carry out the heavy bomber mission in a manner similar or superior to the B-52 and B-1, or if it were equipped with either cruise missiles or ASBMs with a range over 600 kilometers, it would be subject to the Treaty limitations.

2. Subparagraph 2 of Article III of the Treaty provides:

"Each Party undertakes to limit, from January 1, 1981, strategic offensive arms [ICBM launchers, SLBM launchers, heavy bombers, and ASBMs], . . . to an aggregate number not to exceed 2,250 . . ."

3. Subparagraph 1 of Article V of the Treaty provides:

"Within the aggregate numbers provided for in paragraph . . . 2 of Article III, each Party undertakes to limit launchers of ICBMs and SLBMs equipped with [Multiple Independently-Targetable Reentry Vehicle] MIRVs, ASBMs equipped with MIRVs, and heavy bombers equipped for cruise missiles capable of a range in excess of 600 kilometers to an aggregate number not to exceed 1,320."

B. The complement of weapons selected for LRCA, therefore, greatly determines the SALT II implications. There are a number of weapon options with conventional or nuclear variants of each. These are:

1. Gravity weapons;

2. Cruise missiles with ranges less than 600 kilometers;

3. Ballistic missiles with ranges less than 600 kilometers;

4. Cruise missiles with ranges greater than 600 kilometers; and

5. ASBMs with ranges greater than 600 kilometers.

C. A LRCA heavy bomber design which was limited to gravity weapons, cruise missiles or ballistic missiles with ranges under 600 kilometers would result in a non-MIRVed vehicle. It would then be counted in the 930 available slots between the 2,250 aggregate of strategic offense arms and the 1,320 sublimit of MIRVed vehicles. The availability of these non-MIRVed slots for allocation to LRCA is dependent upon the US weapon modernization efforts which convert currently non-MIRVed assets to MIRVed. The weapons subject to SALT II as of the date of the Treaty is specified in an accompanying Memorandum of Understanding.

STATEMENT OF DATA ON THE NUMBERS OF STRATEGIC OFFENSIVE ARMS AS OF THE DATE OF SIGNATURE OF THE TREATY

The United States of America declares that as of June 18, 1979 it possesses the following numbers of strategic offensive arms subject to the limitations provided for in the Treaty which is being signed today:

Launchers of ICBMs	1,054
Fixed launchers of ICBMs	1,054
Launchers of ICBMs equipped with MIRVs	550
Launchers of SLBMs	656
Launchers of SLBMs equipped with MIRVs	496
Heavy bombers	573
Heavy bombers equipped for cruise missiles capable of range in excess of 600 kilometers	3
Heavy bombers equipped only for ASBMs	0
ASBMs	0
ASBMs equipped with MIRVs	0

June 18, 1979

Ralph Earle II

Chief of the United States Delegation to the Strategic Arms Limitation Talks

As a result, we find the current status as:

	MIRVed	Non-MIRVed
ICBMs	550	504
SLBMs	496	160
Bombers	3	570
	1,049	1,234

Therefore, assuming the US is willing to suboptimize on the limits, a portion of the non-MIRVed resources would have to be converted to MIRVed. An example would be conversion of the B-52Gs, and possibly the B-52Hs, to cruise missile carriers. An additional method for reducing the non-MIRVed assets would be to destroy a portion of the B-52s which are counted as bombers, but are not currently in the active inventory (222). A total of 573 bombers are indicated in the SALT II agreement, of these 351 are currently in the active inventory. The remainder are in long-term storage at Davis-Monthan AFB, Tucson, AZ.

B-52 FORCE

MODEL	TOTAL BUILT	FIRST DELIVERY	LAST DELIVERY	ACTIVE INVENTORY TEST	SAC
XB	1	1952	--	-	-
YB	1	1953	--	-	-
A	3	1954	1954	-	-
B	50	1955	1956	1	-
C	35	1956	1956	-	-
D	170	1956	1957	0	79
E	100	1957	1958	2	-
F	89	1958	1959	-	-
G	193	1958	1961	4	169
H	102	1961	1962	0	96
	744			7	344

General Burke has been quoted in the press as indicating that by the mid-1980s the non-MIRVed count will drop to between 600 and 700 leaving between 200 and 300 non-MIRVed slots available for LRCA.

D. A LRCA heavy bomber design which contains a weapons option for cruise missiles with ranges greater than 600 kilometers would be counted under the MIRVed sublimit of 1,320. Available slots in this area are unknown at this time; however, the anticipated conversion of the B-52Gs, and possibly the B-52Hs, would fulfill the MIRVed sublimit. It would, therefore, be necessary for this LRCA variant to supplant existing resources. Additionally, this variant would be limited to an average capacity of 28 such cruise missiles. (See subparagraph 14 of Article IV of the Treaty).

E. A LRCA heavy bomber design which is equipped with the ASBM weapons option (air-to-surface ballistic missile with a range in excess of 600 kilometers), would not be counted in the aggregates. (See subparagraph 5 of Article II of the Treaty). However, the ASBMs themselves would be accounted within the aggregate limit of 2,250. Absent functionally related observable differences (see First Common Understanding under

subparagraph 3 of Article II of the Treaty), all aircraft of the type equipped with ASBM shall be construed as having a full complement of ASBMs. Similarly, if the ASBM is MIRVed, it is accountable under 1,320 sublimit; however, the aircraft itself is not accountable.

F. In summary, assuming the LRCA as ultimately defined is within the definition of a heavy bomber (i.e., capable of carrying out the mission of a heavy bomber in a manner similar or superior to the B-52 and B-1); or is equipped with cruise missiles with a range in excess of 600 kilometers or ASBMs; it is accountable. The most attractive alternative for the LRCA appears to be a unit which is equipped with only gravity weapons and cruise and/or ballistic missiles with ranges less than 600 kilometers. This would permit the LRCA to be accounted within the 930 non-MIRVed slots of which less than 300 are potentially available.

VII. CONCLUSIONS

Selection of the alternative to be pursued is highly dependent upon the exigency of the perceived need which in turn influences the level of program risk that will be accepted. Of the two Milestone II alternatives considered, December 1981 and Fourth Quarter 1985, the December 1981 Milestone II program is of a higher risk. This risk is primarily due to the undefinitized nature of both the "need" and preferred solution concept. Due to the uncertainty associated with these factors, and the known lead-times associated with placing a major system on-line, the December 1981 Milestone II program is not recommended.

The fourth quarter 1985 Milestone II alternative is a much more achievable program, for it permits the necessary mission analysis efforts. These efforts would involve evaluation of ". . . the interplay of threat, capability, operations concepts, survivability, and other facts . . . which bear on the missions . . ." to be performed. They would serve to articulate the mission need and to support the Phase 0 activities by definitizing the principal scenarios.

The mission analyses are a prelude to a more structured program that complies with the major systems acquisition review process. In addition to permitting a more ordered development program, the 1985 alternative would permit the program to use MANTECH options and to realize relief in the leadtimes associated with the production program.

Whichever alternative is selected, the impetus for the LRCA must come from the Milestone 0 decision. For it is that decision which will determine the nature and extent of the entire LRCA program. Until this point, the program is speculative at best. There are, however, key considerations which must enter into that speculation; these include both the realistic constraints of affordability and availability to include such major aspects as materials, manufacturing, and engine development leadtimes.

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GLOSSARY

ADA	-	Advanced Digital Avionics
AFSC	-	Air Force Systems Command
AFR	-	Air Force Regulation
AFWAL	-	Air Force Wright Aeronautical Laboratories
AFWL	-	Air Force Weapons Laboratory
AMP	-	Acquisition Management Panel
AMPR	-	Aircraft Manufacturers' Production Report
ASBM	-	Air to Surface Ballistic Missiles
ASD	-	Aeronautical Systems Division
ATE	-	Automatic Test Equipment
ATS	-	Aircrew Training Systems
CCD	-	Charged Coupled Devices
CFE	-	Contractor Furnished Equipment
D&F	-	Determination and Finding
DFE	-	Derivative Fighter Engine
DoDD	-	Department of Defense Directive
DoDI	-	Department of Defense Instruction
DS	-	Directional Solidification
DSARC	-	Defense Systems Acquisition Review Council
DSE	-	Directional Solidification Eutectics
DX	-	(Defense Priority)
EPA	-	Extended Planning Annex
FLIR	-	Forward Looking Infrared
FSED	-	Full-Scale Engineering Development
FTD	-	Foreign Technology Division
FYDP	-	Five-Year Development Plan
GAO	-	General Accounting Office
GE	-	General Electric
GFE	-	Government Furnished Equipment
ICs	-	Integrated Circuits
ICA	-	Independent Cost Analysis
ICAM	-	Integrated Computer-Aided Manufacturing
IOC	-	Initial Operational Capability

JAMAC	-	Joint Aeronautical Materials Activity
LCC	-	Life Cycle Cost
LRCA	-	Long Range Combat Aircraft
LSA	-	Logistics Support Analysis
LSI	-	Large Scale Integration
MANTECH	-	Manufacturing Technology
MENS	-	Mission Element Needs Statement
MIRVed	-	Multiple Independently-Targetable Reentry Vehicle
MNOS	-	Metal Nitride Oxide Semiconductor
MTIS	-	Manufacturing Technology Investment Strategy
NDI	-	Non-Destructive Inspection
N/C	-	Numerically Controlled
O&S	-	Operation and Support
OMB	-	Office of Management and Budget
OPEC	-	Organization of Petroleum Exporting Countries
PABST	-	Primary Adhesive Bonded Aluminum Structures
PCBS	-	Printed Circuit Boards
P^3I	-	Pre-Planned Product Improvement
PM	-	Powder Metallurgy
POM	-	Program Objective Memorandum
PRRs	-	Production Readiness Reviews
RAM	-	Radar Absorbing Material
RCS	-	Radar Cross Section
RDT&E	-	Research, Development, Test and Evaluation
RFP	-	Request for Proposal
ROI	-	Return on Investment
RSR	-	Rapid Solidification Rate
SAC	-	Strategic Air Command
SAB	-	Scientific Advisory Board
SALT	-	Strategic Arms Limitation Treaty
ADDM	-	Secretary of Defense Decision Memorandum
SECAF	-	Secretary of the Air Force
SECDEF	-	Secretary of Defense
TAC	-	Tactical Air Command
TWT	-	Traveling Wave Tube

USAF	-	United States Air Force
VHSIC	-	Very High Speed Integrated Circuits
VLSI	-	Very Large Scale Integration